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EMPLOYMENT OF THE ENGINEERING GRADUATE

By GEORGE C. SHAAD

Vice-President of the Society

A report on the status of the employment of the engineer, more particularly as it concerns the teaching of engineering and relations of engineering teachers to graduates and alumni, is tentatively on the program for the Atlanta convention, and to the writer has been assigned the task of collecting information essential to such a report. He will need the advice and aid of the the society membership, as well as any other agencies, and this is an invitation for suggestions as to specific topics for consideration in such a report. He also craves your indulgence should you later be troubled by questionnaires from the committee which will be organized to conduct the details of the work.

That such a study is timely is shown by directly conflicting statements regarding the need for technically trained men in the near future: we find a personnel officer of one very large industry telling us that never again will the demand for technical graduates be as great as it has been in former years even though business should return to and exceed the 1929 level; and, over against this, the prophesy of others, situated equally advantageously for judgment of the question, that the next few years will see a shortage of men so trained. Who is correct? It is hoped that our study will shed some real light on the subject. If the normal channels into which our graduates have gone in the past are to be partially closed, may not the field be expanded by opening up new opportunities, either by discovering additional occupation to which our product is especially well adapted through the training as provided at present, or by widening the outlook through changes in the training offered by the engineering schools?

To what extent, if any, are our schools responsible for the employment of a graduate, either immediately after graduation or in later years? Practices as to aid in employment differ materially in our various schools. A little clearer conception of our function in the matter is desirable. Meanwhile, our enrollments in engineering schools, in common with the numbers pursuing other types of higher education, is increasing. Should we tell prospective engineers that the field is limited, as it happens to be at the present date, or can we assure our students that their chances for remunerative employment as well as the rendering of a real service are reasonably good? It is hoped that we can partially answer many questions of this character at the Atlanta meeting.

YEAR ROUND OPERATION OF S. P. E. E. THROUGH COMMITTEES

The potentialities of S. P. E. E. can be most fully attained by year-round operation through committees. The possibilities of committee effectiveness was glimpsed at Ithaca. The technical engineering societies are now utilizing this means for carrying on a continual advance. A convention has its proper and unique function, but the detailed attention of committees is required to collect data, make observations, remove the unessential, check obscure relationships, and to coördinate and evaluate the factors involved in a situation. Engineering education, like other social problems, requires group thought and experience for the best solution.

No phase of engineering education has reached a static condition. Education is an evolving or growing function, shaped by an infinitude of human factors. New instrumentalities, changed social and economic demands on the profession, and adjustments to meet varying preparation of students, constantly alter the pattern. Therefore, our educational equation is one involving many variables rather than constants and our methods of solutions must be designed accordingly.

The annual convention should see the culmination of the year's work of the committees as well as offer a high point of inspiration to the membership for viewing the way ahead. Time must be available for an adequate presentation and consideration of committee findings without displacing the individual papers and discussions. Each has its function, and the two features of the program must be coördinated so that the peculiar values of each can be realized.

Each member of a committee should communicate at once his views concerning the committee program to its chairman, and the chairman should soon circulate his plans for the year to the members of his committee. Committees should draw on the membership for any coöperation desired and any member should feel at liberty to make suggestions to a committee. The devices available for committee operations include correspondence, questionnaires (with discretion), assignment of special inquiries to sub-committees or to individual members, industrial or other extra-Society conferences, and studies at particular colleges. If the light generated by such committee activities be brought to a focus at the convention, it cannot fail to illumine the entire field of engineering education.

The times require a scrutiny and, perhaps, a re-defining, of objectives in engineering education. The power to do this lies latent in the Society, for it contains the necessary variety of viewpoint, the open-mindedness, the grasp of practical aspects and the experienced judgment within its membership. No outside agency has the combination. If the course of engineering education is not charted with discernment in the new era ahead, the failure will be our own. Thoughtful continuous effort by committees is our best reliance.

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THE EDUCATIONAL BACKGROUND OF CERTAIN DISTINGUISHED ENGINEERS

By C. FRANK ALLEN

Professor Emeritus, Massachusetts Institute of Technology

The writer can look back many years to his disturbance of mind caused by the oft asserted claim that the ideal education for the engineer is graduation from a college of arts supplemented by graduation in engineering. The writer's ideal long since has been in the direction of the regular four years of engineering education supplemented by further graduate study in engineering, provided that more than four years are to be devoted to formal education of college grade, reference to which will be made later. His opinion has been based, he believes, primarily upon his observation of the success attained by acquaintances who had pursued graduate study in engineering.

In theory the procedure appears sound. The young man one step in advance of his fellows has been found to have an advantage not alone in securing preference of employment. Even of more importance is his opportunity for proving of greater value to his employer and thus finding himself in line for assignment to work which affords a chance for further development as well as advancement. In this connection there may be cited two examples of advice given to young engineers: "The important thing is to do your job better than your employer expects you to do" and "It is more important for you to be worth $250 per month than for you to receive it."

In the history of one of the most highly honored of the members of this society, his early advancement in the field of teaching and his rare opportunity for gaining an enlarged experience in engineering practice came from the fact that he was a long step ahead of his contemporaries in analyzing the cause of a serious railroad accident, a step ahead clearly due in that case to extended graduate study. There is undoubtedly a definite advantage technically.

But how about the broader aspects? It seems wise to sidestep the word "culture" in this connection as the conceptions of its meaning differs so widely. To some, culture lies outside of contact with things directly useful; to others it means an acquired appreciation of things worth while; to others it is very vague.

We can agree that education and book learning are not synonymous terms. A professor from the great French School of Engineering, speaking at the University of Zurich, once outlined in their order the five qualifications for the successful engineer: Character, Intellect, Scientific Foundation, Knowledge of Men, Knowledge of Engineering. A reasonable interpretation of this pronouncement is in part that knowledge of men outranks book learning.

Following this line of thought, the writer is impressed with the belief that the educational value of association with graduate students for a year or more will far outclass the value of the association with the somewhat immature undergraduates of an arts college as an alternative, even with some disparity in the duration of the association. In furtherance of this view, at the engineering college with which the writer is most familiar, the college "Review" some years ago contained a symposium from the experiences of a number of professors who had studied abroad, in physics, chemistry, or engineering. This was in Germany. The sentiment was well defined that, at that time, it was not essential for adequate technical instruction to leave this country, but all were enthusiastic as to the value of their life abroad; their education aside from the training, which in this case was of course scientific foundation rather than book learning. What was the educational value of their contact with picked men from many colleges and from various countries?

Not all the advantages which these men then received from life and study in Germany are now available. However, within our own country one well-known engineering college maintains a graduate school of five hundred students, three hundred of whom are engineering students, in addition to chemists, physicists and others. These men came from more than one hundred educational institutions and from many states as well as from foreign countries and with varying engineering educational backgrounds. In this graduate school there is a primary nucleus of men of required high standing from graduates of its own college. Others who apply are selected with care and must afterwards meet the standards established by its own graduates; many of them do this with distinction. Special dormitory facilities are provided for graduate students where desirable contacts, social and educational, may be enjoyed. At other engineering colleges, opportunities not dissimilar exist, not always for as large numbers, but in such cases often with adequate compensations.

This much for theory from the writer's standpoint. Are facts available to constitute a reasonable means for testing results? It occurred to the writer that a suitable measuring stick might be

found in the records of the educational background of those who have been presidents of the four Founder Societies of engineers; Civil, Mining, Mechanical and Electrical. Tabulations follow covering each of these societies separately. Once this measuring stick is accepted and adopted, the opportunity for discrimination or bias on the part of the compiler is reduced to a minimum. If the heads or prominent officials of large industries, large corporations, were to be considered, questions would properly arise as to which of these ought to be considered or as to which should greater weight be accorded. The compilation has proceeded, then, upon the basis decided upon.

It was early found that the data at hand allowed the scope of the investigation to be considerably broadened beyond what was originally contemplated. While the original inquiry has been substantially covered, other points of interest have been suggested. Except for this, the paper might have seemed unworthy of presentation.

The tabulations require some preliminary explanations. The names of presidents have been arranged in the order of the year of their birth, the better to reflect their educational advantages. It is thought that those born earlier than 1844 had less opportunity for education in an engineering college than those born later. For those born earlier than 1844, there were available only Rensselaer, the Lawrence and the Sheffield Scientific Schools, West Point and Annapolis, together with a few little known courses in science in a few colleges, leading sometimes to the degree of Ph.B.

The "Year President" column records the first year of presidency; several presidents served a second term. Study short of graduation, either in a college of arts or of engineering, is classed as "No College Degree." Graduate Engineering Study following a Degree in Engineering is recognized and tabulated whether leading to a degree or not. As an example, one president, a highly distinguished president of the Society as well, spent three years in Germany in extensive graduate study and essentially completed the engineering courses in structures, hydraulics and railroads given there, but was ineligible to a degree since this was restricted to those entering government service.

On the other hand, in the tables, engineering study following a Degree in Arts demands graduation in engineering and is then entered as "Degree in Engineering." This system is believed to be logical and fair. Honorary Member and Society Medals are confined to those distinctions (including prizes as well as medals) granted by one of the four Founder Societies. Honorary Degrees are confined to those of the rank of Doctor; an honorary A.M. or S.M. is not considered. How much weight should be given even to

an honorary degree of Doctor rank is uncertain. The sources of information available have not always been up to date and there seems to be no standard governing the action of different colleges or as to the comparative weight to be given them. The records, however, have some value and are included for what they may appear to be worth. An absence of an honorary degree may be due simply to a lack of available information. A positive item does present some value.

The attention of the writer is therefore devoted largely to a consideration of the records of the educational background of those born in 1844 or later, as it has been found that graduates in 1844 or later in the middle west as well as in the east have acquired distinction and are included in the later discussions. A line has been drawn to separate those born before 1844 from those born later. A condensation of data follows:

NUMBER OF PRESIDENTS BORN LATER THAN 1843 IN EACH OF THE CLASSIFICATIONS

	No College	Arts	Engineering
Civil	9	0	20
Mining	5	9	28
Mechanical	15	3	17
Electrical	12	3	31
Totals	41	15	96

Omitting those whose names occur in more than one Society or more than one column the total is 142.

Another condensation tabulates in each class of engineering the number born since 1843 of No College Degree; of those having only Degree in Arts; and of those having only Degree in Engineering without the addition either of a Degree in Arts or of Graduate Study.

NUMBER OCCURRING IN ONE COLUMN ONLY

	No College	Arts Only	Engineering Only	Totals
Civil	9	0	17	26
Mining	5	3	14	22
Mechanical	15	2	16	33
Electrical	12	1	15	28
Totals	41	6	62	109

Still another condensation tabulates those who had a Degree in Arts supplemented by a Degree in Engineering, compared with those who had a Degree in Engineering supplemented by Graduate Study in Engineering.

NUMBER OF ARTS PLUS ENGINEERING *vs.* ENGINEERING PLUS GRADUATES

	Arts plus Engineering	Engineering plus Graduate	No College	Totals
Civil	0	3	9	12
Mining	6	8	5	19
Mechanical	1	1	15	17
Electrical	2	15	12	29
Total	9	27	41	77

Looking again at these tabulations and the groupings as a whole for the period following 1843, one's attention is attracted to the long rows of those who took their Degree in Engineering. It will be remarked that this is only what should be expected. Yes or perhaps. It certainly is satisfying. Next, it seems rather unexpected that the columns of Degree in Arts should make so poor a showing, whether supplemented by a Degree in Engineering or otherwise. Again, the excellent showing, on the whole, of the "No College Degree' records was hardly anticipated. To be sure there are few of these in Mining or in the later years of Electrical. There are many in Mechanical, and a good sprinkling in Civil, and a fine showing in the earlier years of Electrical of which notice will be taken later.

There are several points of view touching this feature. The tables also show the Civil and the Mechanical engineers to be of greater age at Presidency than the Mining and the Electrical Engineers. The two phenomena, a larger number of No College Degree and also greater age, fit in well with the fact that success in Civil Engineering depends to a greater extent upon judgment based upon experience which comes with age, and less upon technical attainments which appear to be of greater importance, more essential, both in Mining and in Electrical engineering. The selection of sites, river and harbor work, the distribution in water or of drainage systems, are of the kind noted. The writer, with some distrust, ventures to suggest also that mechanical engineers, too, have succeeded largely from judgment based upon experience, resting in part upon precedent. The business interests of mechanical engineers in shops and factories may have been a factor also. More and more, however, does it become true that the graduate of the axe

handle (to use a civil engineering term) will succeed only by virtue of acquiring with greater difficulty the engineering qualifications of the technically trained engineer, but with some advantage involving the time element and the necessity of concentrating on major principles as compared with the technical student who, as we know, has often an inordinate appetite for details. One highly distinguished president listed under No College Degree, has stated:

> There were no technical colleges in existence in England or in this country which gave bachelor degrees in engineering, so I had to make my own path. It meant much extra work but perhaps that brings a certain compensation.

The compensations have been in part overcoming obstacles from doing which comes much of the joy of life; in part in cultivating self reliance: digging out problems rather than receiving instruction; doing things and observing things done in engineering; acquiring business experience and the methods and habits of his superiors to whom he reports. Nor has he been without instruction. In some lines of engineering he is an apprentice. In civil engineering sixty or seventy years ago a "student" paid his employer $100 per year for "instruction." This instruction consisted in part of an opportunity to see and learn and in part the direction of his efforts and studies by his employers, using perhaps the principle stated by a gruff doctor, a professor in a medical college, "I can't teach these chaps anything; all I can do is set them at work." Moral, teach less, educate more.

There is another element to be considered. Many of the No College Degree men, whatever their desire and purpose, were unable for financial or other reasons to secure the education of an engineering college. They succeeded by virtue of a most important precept or principle: "They took advantage of the opportunities they had." Successes or failures well-nigh innumerable have hung upon the observance or otherwise of this principle. With recognition of the fact that definite values have been gained by the man who rose to the top without a college degree, nevertheless, from the data compiled here, it appears to be true that the completion of a course in a college of engineering to the deserving and acquirement of a degree offers the best opportunity for success for those to whom this is possible. The president above quoted, in an Aldred lecture, an endowed lecture at an engineering college, after citing character as the prime requisite for engineering success, stated to his student audience that "habit is an important element of character." He called attention to the careful and accurate observation of facts and the mathematical or other processes following, as building character, for correct results do not come if error intervenes.

A pamphlet issued by The Engineering Foundation defines engineering as a "habit of thought." The writer prefers the slightly different term, "habit of mind," and this he believes is part of what is acquired in the training in the College of Engineering. The pamphlet further states, "Not only must an engineer be accurate, but he must know when he is right and why. He must work in conformity to natural laws, for no amount of wishfulness or mental chicanery can change them. Early in his career he learns that truth alone prevails." This outlines one element at least of character.

From another source, an able editor of an engineering journal, came the statement that "one element of an engineering education is that it enables you to look a fact in the face."

The conditions with the electrical engineers were somewhat different from those above referred to. What was essentially a new science has sprung up over night. Among the early engineers in the field, Bell, Weston, Thomson, Carty, Kennelly and Rice are names with which to conjure. Their records here are testimonials to that effect. These men were pioneers, inventors, carrying on research in their own laboratories at a time when colleges had not acquired equal facilities. These were all in the No College Degree class. In later years, Graduates in Engineering have held the lead. It will doubtless be granted that the practice of electrical engineering is more highly technical than that of the other three branches of engineering and now requires systematic engineering education.

The absence of the name of Steinmetz from those just mentioned may attract attention. Apparently he received through special instruction an education at least adequate for a Degree in Engineering but was not in line for a degree. He has been ruthlessly assigned to the No College Degree column. In this connection another case may be noted, that of T. M. Drown in Mining Engineering. Dr. Drown received a degree of M.D., after which he spent three years at the Sheffield and Lawrence Scientific Schools without receiving a degree, followed by study at Freiberg, Heidelberg and Paris but with no record of a degree. It is improbable that he received one. Altogether his record indicates an education more extensive than a Degree in Engineering plus Graduate Study. In substance these men had an engineering education adequate for a degree. On the other side of the ledger, one president received a degree of Ph.D. following a three years course in Geology, perhaps science rather than engineering, but this was the basis of his election to the presidency. He was classed as Arts plus Engineering. In the same direction, H. M. Howe, also of Mining Engineering, was the recipient of three medals of very high grade not recorded here because granted by outside bodies.

There are bound to be inequities in a compilation of this sort upon a somewhat rigid basis, but it is fair to say that any variation can hardly vitiate any conclusions to be reached here.

What about the Graduate in Arts? In his four years in college he has secured neither the experience and other advantages of the No College Degree man, nor the "habit of mind" of the engineering college, which is not imaginary but a reality and a real asset; something which hardly exists in the arts college where memory usually plays a large part; while on the other hand, close reasoning is certainly essential in engineering courses. The memory habit is not always easy to eradicate. Even in one of the writer's classes, a mature student who had failed at examination, exclaimed at a special tutoring exercise: "I see what you are after; you want me to use my good sense instead of my memory." This was in a subject essentially geometrical. He had then and there acquired something of the habit of mind referred to and which was further developed later.

A skilled teacher in a well-known large university once stated to the writer: "When I get to summer camp, I can teach Applied Mechanics there." President Dodds of Princeton was thus quoted in part in the newspapers of April last: "Admitting that the first two years in American colleges have been, if not a total loss, at least a serious loss." Irrespective of the loss of time, what has happened to the habit of mind? In any case the Graduate in Arts is two or three years behind the Graduate in Engineering in preparation for an engineering career. It would be futile to suggest that the Graduate in Arts cannot have acquired a habit of mind adequate for an engineering career, but to what extent will he do so? As we all know, fine students have come to us from arts colleges. In the writer's experience, however, the men who have come up directly through the engineering courses have rather more than held their own working side by side. Whatever may be the explanation of the slim showing in the Degree in Arts column. whether this or some other, it is improbable that it is purely accidental. No more should the fairly favorable showing of the No College Degree be regarded as accidental.

Reverting to the table contrasting the Degree in Arts plus Engineering with Degree in Engineernig plus Graduate Study, it appears that omitting one record which includes both classes, there remain 9 in Arts plus Engineering, 27 in Engineering plus Graduate, and no less than 41 in No College Degree. While the greatest number in engineering columns appears in electrical, about half of these fifteen were graduated in other courses than electrical engineering and the Graduate Study was not in all cases in electrical engineering. From the writer's standpoint it is true that there is

greater advantage or necessity in advanced or graduate study in electrical engineering than in the other branches, yet the choice the students had originally made was not arts, but was engineering, well distributed among the different branches and it is not unfair to contrast the total tabular values. It is a well-known fact that a graduate in one branch of engineering has time and again attained high success in some other branch.

It appears from an examination of the Register of Graduates of a large engineering college for several years, that there was a slight preponderance of students in Arts plus Engineering, as contrasted with Engineering plus Graduate Study. There existed at least equal opportunity. There appear to be no data available to consider equality of opportunity as to No College Degree engineers. The comparatively large number of these together with the still larger number of Degree in Engineering only, prompts a question as to the advisability of more than the standard four years of engineering education leading to the degree. Confessing some bias towards graduate study, the writer finds himself leaning towards the opinion that for a considerable majority of young men it is unwise to maintain the student attitude or habit for more than four years of engineering college work. Without doubt some will profit by additional study; apparently others prosper more from earlier acquiring business habits and a better knowledge of the world; in gaining experience more gracefully while of earlier age. Among the writer's friends, two whose names occur in the tables stand out for quality. One of them succeeded largely by nature of his extended studies; the other, perforce, started into work immediately following graduation; it seems probable that additional study, graduate study, would not have added to his success. Of the two records, both superior, the latter is not inferior to the former. The logical conclusion is that for some, graduate study should follow graduation and for others not. In many cases the choice could easily be made; in others the proper course of action would be obscure. In not a few cases, success would follow either course. From this standpoint, there seems little argument in favor of electing at the start a course in arts in preparation for a career in engineering. So far as these statistics indicate, if a young man expects to qualify as an engineer, hoping for distinction, he should enter an engineering college if finances and physical conditions warrant. Otherwise the young man neglects "to take advantage of the opportunities he has." He might be able to make a connection with an engineer willing to direct his efforts and to provide opportunity for experience, a course far more difficult than in the earlier years. Another disadvantage in entering upon the arts course is that in the event of financial reverses or disabling illness, the Graduate in

Arts at the end of his four years has landed nowhere as far as opportunity or preparation in engineering is concerned.

The inconspicuous part which the Degree in Arts appears to have in acquiring distinction in engineering raises a question as to what amount of general or non-technical courses should be given in engineering colleges. Some years ago it was said that a well educated man should "know something of everything and everything of something." Such a result is now clearly unattainable.

It is safe to assume that nobody knows what should be the exact balance between general and professional studies; probably it is not the same for different individuals. Apparently the balance largely in use in our engineering colleges is effective and should not carelessly be disturbed. The records shown here indicate this. This Society will not endorse abandonment or any serious let-down in non-technical studies. The writer was impressed with the full day devoted to the study of English at the meeting in 1933. The faculties of our engineering colleges also have developed a resistance to any weakening of general or non-professional studies.

From the data contained in the tables it seems apparent that distinction in engineering in the line covered by these tables rests more upon engineering acquirement than upon general breadth or non-technical training. This point of view is supplemented by the fact that at the recent Commencement of an engineering college 178 degrees were Master's or Doctor's degrees conferred for graduate work, more than one-fourth of all the degrees granted.

Furthermore, it was stated that 80 per cent of the graduate students had been placed as compared with 60 per cent of the graduating class. The demand from employers was for the more deeply trained men and the demand from the students for advanced study was emphatic.

The writer believes that it is important that a sturdy resistance should be cultivated against inroads upon the engineering curriculum, a danger at this time not imaginary, the pressure coming quite largely from those not teaching engineering subjects.

Some experiments have been made bearing upon the emphasis to be given to non-technical subjects. The proposition was at one time entertained that the college of engineering should be a graduate school in the sense that schools of law and of medicine are graduate schools in several of our universities. The foregoing records and discussion would appear to apply here also. Further than this, one university did, not long since, inaugurate a Graduate School of Engineering, admission to which was restricted to graduates, but this was shortly discontinued. This graduate school, however, has been revived under changed provisions. Its faculty now "is also responsible for instruction in the Undergraduate

School of Engineering," so that instruction in engineering there is no longer restricted to graduates.

Another experiment was made when one of our universities some years ago set up a six years combined course in arts and engineering, concerning which a prominent member of our Society, at that time teaching there, irreverently remarked that "it might be a good course if anyone took it."

Looking at the matter from another standpoint, it is recognized by us that our graduates are not engineers but have secured an adequate foundation upon which to build. Do we not carelessly over-estimate what the Graduate in Arts has secured? Not yet a liberal education, but an introduction to one. The Graduate in Engineering, also, has secured an introduction to a liberal education, less in quantity, but commonly of excellent quality due to habits of earnest study. When a Graduate in Arts enters the junior year of an engineering college, he has spent considerable time in mathematics, chemistry and physics, and the engineering student is not too far in the rear as to the general or liberal studies, certainly if President Dodds is correct and not too pessimistic. Most of any man's liberal education is acquired after graduation, or by non-graduates through their own efforts. Men of good parts develop or rise to the occasion as circumstances demand. This is illustrated by the experience of the writer some years since in finding that in conciseness and directness in discussion, the engineering members of the American Railway Engineering Association compared favorably with the members even of our own Society. Necessity has taught them not to waste time nor to be unprepared when they appeared before their general manager. Again, few engineering students have acquired sufficient facility to use French or German as a tool. The foundation is there and the necessary facility can be acquired later. Additional facility at the expense of training in engineering would be a mistake. The function of the engineering college is to do for the student what he could accomplish either not at all or with considerable difficulty and disadvantage otherwise. That is, to teach him theory, and this can be taught to the best advantage in connection with its applications. After a reasonable introduction, many non-technical subjects can be studied to advantage later outside the college.

The writer has also briefly and broadly made a cross section of the activities of these presidents but the results will not be elaborated here. However, there is found to be a considerable spread in the engineering activities in each society, indicating to the writer's mind the importance of the general fundamental engineering training in undergraduate work which engineering colleges supply. There has been necessity also for somewhat fundamental

specialization in the direction of what seems essential for different branches of engineering, and so far as the subjects covered are not lacking in training value, the practice has seemed sound. Tracing engineering education historically the trend has been in the direction of specialization to this extent in spite of vigorous protests against it, and who shall say that the history is not of progress? Higher specialization and research doubtless belong to graduate study.

The tabulations are records of results now obtainable. They tell us what has happened in the past. The future may furnish data to modify such conclusions as we may now venture, but the general scheme of engineering education has been steady rather than fitful, and sudden changes are improbable. It would be interesting if someone would gather further statistics as to the success or otherwise of Graduates in Engineering in industries depending largely upon engineering, as also upon lines of business not commonly associated with engineering, for the writer professes great enthusiasm for engineering education as a preparation for general business.

Following the brief discussion of the paper, it seems desirable to somewhat clarify the tables in some particulars. Toward this end, to better set forth the facts, the tables have been amplified by adding columns of Degree or Graduation and also the Colleges from which these were received, except that the names of the European colleges have not been specified partly because they are less familiar to us and abbreviations largely would mean little. For typographical reasons, the amplifications for Arts plus Engineering and Engineering plus Graduate Study have been shown in a separate table.

Furthermore the writer finds that he has been and is concerned with the substance rather than fine technical distinctions. It is realized that Graduation and Degree are essentially synonymous terms; in some cases graduation only is specified in the data available for the tabulations. The columns, Degree in Arts or in Engineering would better have been headed Graduation in Arts or in Engineering. Polytechnic Institutes, Schools of Applied Science and Institutes of Technology are designated as Colleges, Colleges of Engineering, as are West Point and Annapolis, and also the Sheffield and the Lawrence Scientific Schools. Graduates of West Point and Annapolis, then, are classed under Degree in Engineering. They number, of those born later than 1843, five in all, graduates of Annapolis, one of whom is recorded in the Engineering plus Graduate column.

The form of degree varies largely. In earlier years Brown and

Sheffield granted the degree of Ph.B. for courses which could be called engineering courses. Wm. A. Anthony whose name occurs in the discussion, studied engineering at Brown, then transferred to Sheffield, where he received the degree of Ph.B.

The degree of Ph.D. has been questioned, whether or not a Degree in Engineering, specifically in the cases of Samuel Sheldon and F. B. Jewett. It seemed reasonable to assume that a Ph.D. followed by a career in Engineering was properly classed under Graduate Engineering Study. This seemed especially true as to electrical engineering. The first course by that name leading to a degree grew out of an option in a Course in Physics. In point of fact Sheldon on his return from Europe became Professor of Physics and Electrical Engineering at Brooklyn. Jewett studied technical electric courses for a half year and became an Instructor in Physics and Electrical Engineering at M. I. T. M. I. Pupin, on his return from Europe, taught mathematical physics in the newly organized Department of Electrical Engineering at Columbia. Louis Duncan, two years after receiving his degree of Ph.D., became Associate Professor of Applied Electricity at Johns Hopkins. Wm. McClellan, two years after receiving his degree, was engineer with Westinghouse, Church, Kerr & Co. J. P. Whitehead took his advanced degree while teaching applied electricity at Johns Hopkins.

It is difficult to differentiate between a course in science and a course in engineering. The degree of S.B. or B.S. is technically a degree in science but is the degree very largely given to graduates in engineering. As an instance, Harrison P. Eddy received from the Worcester Polytechnic the degree of B.S. in chemistry. His training in that subject was his definite and immediate qualification for employment in Sanitary Engineering which has continued his specialty for more than 40 years. The degree of Ph.D. granted to George Otis Smith represented three years of graduate work in geology, a subject of prime importance in mining engineering. It doubtless was the basis for his election to the presidency. He has been classed under Arts plus Engineering.

The matter of degrees in European colleges is not well understood by the writer who, however, does know that the satisfactory completion of studies there is not always rewarded with degrees. The proper entry is not always clear. Specifically, it is probable that Henry Flad's graduation was in Engineering; perhaps not. Alphone Fteley probably was first graduated in Arts; perhaps not. Max J. Becker's case is uncertain. Eckley B. Coxe received the degree of A.B. at University of Pennsylvania, and studied further there before going to Europe for engineering courses. The extent and quality of work which he did seems to justify granting it the

equivalent of Graduation. Perhaps Dr. T. M. Drown should have the same treatment. His preliminary degree was M.D. Possibly Richard Pearce and E. D. Meier may each be entitled to Degree in Engineering rather than No College Degree, but the evidence seems insufficient. All of these were born earlier than 1844. Of those born later Albert R. Ledoux, born 1852, studied three years at Columbia School of Mines and two years more at Berlin. This seems an equivalent to a Degree in Engineering especially when supplemented by a Ph.D. at Gottingen. The facts in these cases are more important to the reader than the entry made in the table, and the writer has attempted to present facts as far as feasible.

In these tables, several presidents became Honorary Members of more than one society. The medals or prizes were granted either by a separate society or by the four combined.

The writer is unwilling to claim perfection in these tables. Data have been secured from Who's Who, from the National Cyclopedia of American Biography and other Cyclopedias, from records of the societies as well as of colleges, and also from personal correspondence. These records have not always given complete information and in one or two cases have shown inconsistencies. They are further liable to faulty interpretation which, however, has been intentionally judicial, wheresoever it pointed. Some corrections and additions have been made since the paper was read at the convention. The writer is, however, firm in his conviction that any changes made or any errors which may now possibly exist, will not affect the discussion in the text which has not been changed except for clerical corrections which include slight changes in the numbers given in the condensed tables. It has been the writer's purpose to furnish data such that the reader can draw his own conclusions.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Name of President	Year of Birth	Year President	Age at Presidency	Degree or Graduation	College	No College Degree	Degree in Arts	Degree in Engineering	Graduate Engineering Study	Honorary Member	Society Medals	Honorary Degrees
George S. Greene	1801	1875	74	Grad.	W. Pt.			×		×		
Horatio Allen	1802	1871	69	Grad.	Clmb.		×			×		
James P. Kirkwood	1807	1867	60			×						
Ashbel Welch	1809	1882	73			×						
Alfred W. Craven	1810	1869	59	A.B.	Clmb.		×					
Wm. M. Roberts	1810	1878	68			×						
James Laurie	1811	1852	41			×						
Wm. J. McAlpine	1812	1868	56			×				×		
Julius W. Adams	1812	1873	61			×				×		
Ellis S. Chesborough	1813	1877	64			×						
James B. Francis	1815	1880	65			×				×		
Frederick Graff	1817	1885	68			×						
Wm. E. Worthen	1819	1887	68	A.B.	Harv.		×			×		
Thomas C. Keefer	1821	1888	67			×				×		
Henry Flad	1824	1886	62	Grad.	Eurp.			×				
Albert Fink	1827	1879	52	Grad.	Eurp.			×				
Thomas C. Clarke	1827	1896	69	A.B.	Harv.		×					
Max J. Becker	1828	1889	61	Educ.	Eurp.	×						
Charles Paine	1830	1883	53			×						
Don J. Whittemore	1830	1884	54			×				×		
Charles Hermany	1830	1904	74			×						
Mendes Cohen	1831	1892	61			×						
Octave Chanute	1832	1891	59			×					×	
Wm. P. Craighill	1833	1894	61	Grad.	W. Pt.			×		×		
Wm. P. Shinn	1834	1890	56			×					×	
John J. R. Croes	1834	1901	67	A.B.	St. Ja.[5]		×				×	
Benjamin M. Harrod	1837	1897	60	A.B.	Harv.		×					
Alphonse Fteley	1837	1898	61	Grad.	Eurp.		×	×			×	
Charles Macdonald	1837	1908	71	C.E.	Rens.			×				×
William Metcalf	1838	1893	55	Grad.	Rens.			×			×	
Robert Moore	1838	1902	64	A.B.	Miam.		×					
Elmer L. Corthell	1840	1916	76	A.B.	Brwn.		×					×
George S. Morison	1842	1895	53	A.B.	Harv.		×					
Clemens Herschel	1842	1916	74	S.B.	Lawr.			×	×	×	×	×
Charles C. Schneider	1843	1905	62	Grad.	Eurp.			×			3	
Fayette S. Curtis	1843	1919	76			×						
Alfred Noble	1844	1903	59	C.E.	Mich.			×			×	×
Mordecai T. Endicott	1844	1911	67	C.E.	Rors.			×				
Desmond FitzGerald	1846	1899	53			×				×	2	
George H. Benzenberg	1847	1907	60	C.E.	Mich.			×				2
John A. Ockerson	1848	1912	64	B.S.	Ills.			×				×
Onward Bates	1850	1909	59			×				×		3
Frederick P. Stearns	1851	1906	55			×					×	×
John F. Wallace	1852	1900	48	C.E.	Woos.			×			×	2
John F. Stevens	1853	1927	74			×				×	×	3
George H. Pegram	1855	1917	62	C.E.	Wsh. U.			×		×		×
George S. Webster	1855	1921	66	C.E.	U. Pa.			×				×
John R. Freeman	1855	1922	67	S.B.	M. I. T.			×		2	4	5
Carl E. Grunsky	1855	1924	69	Grad.	Eurp.			×			×	2
George S. Davison	1856	1926	70	C.E.	Rens.			×				2

AMERICAN SOCIETY OF CIVIL ENGINEERS (*Continued*)

Name of President	Year of Birth	Year President	Age at Presidency	Degree or Graduation	College	No College Degree	Degree in Arts	Degree in Engineering	Graduate Engineering Study	Honorary Member	Society Medals	Honorary Degrees
George F. Swain	1857	1913	56	S.B.	M. I. T.			×	×	×		2
Charles D. Marx	1857	1915	58	B.C.E.	Corn.			×	×	×		×
Arthur N. Talbot	1857	1918	61	B.S.	Ills.			×	×	×	×	3
Charles F. Loweth	1857	1923	66			×						
Lincoln Bush	1860	1928	68	B.S.	Ills.			×		×		×
Hunter McDonald	1860	1914	54			×						
Arthur P. Davis	1861	1920	59	B.S.	G. Wsh.			×				2
Robert Ridgway	1862	1925	63			×						×
John A. Bensel	1863	1910	47	M.E.	Stev.			×				
Anson Marston	1864	1929	65	C.E.	Corn.			×				
John F. Coleman	1866	1930	64			×						
Francis L. Stuart	1866	1931	65			×						
Herbert S. Crocker	1867	1932	65	B.S.	Mich.			×				
Alonzo J. Hammond	1867	1933	66	B.S.	Rose			×				
Harrison P. Eddy	1870	1934	64	B.S.	Worc.			×			2	

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

Name of President	Year of Birth	Year President	Age at Presidency	Degree or Graduation	College	No College Degree	Degree in Arts	Degree in Engineering	Graduate Engineering Study	Honorary Member	Society Medals	Honorary Degrees
David Thomas	1794	1871	77			×				×		
Abram S. Hewitt	1822	1876	54	A.B.	Clmb.		×					
John Fritz	1822	1894	72			×				2		3
T. Sterry Hunt	1826	1877	51			×					×	
A. L. Holley	1832	1875	43	A.B.	Brwn.		×					
Thomas Egleston	1832	1887	55	Grad.	Yale		×	×				2
Wm. P. Shinn	1834	1880	46			×					×	
Richard P. Rothwell	1837	1882	45	Grad.	Rens.			×	×			
Richard Pearce	1837	1889	52	Educ.	Eurp.	×						×
William Metcalf	1838	1881	43	Grad.	Rens.			×			×	
Robert W. Hunt	1838	1883	45			×				2	×	
Eckley B. Coxe	1839	1878	39	A.B.	U. Pa.		×	×				
J. L. Weeks	1840	1895	55	A.B.	Wesl.		×					
R. W. Raymond	1840	1872	32	Grad.	Brkl.			×	×	×		2
Thomas M. Drown	1842	1897	55	Educ.	Eurp.	×				×	×	×
Robert H. Richards	1844	1886	42	S.B.	M. I. T.			×		×		×
John Birkenbine	1844	1891	47			×						
James C. Bayles	1845	1884	39			×						
E. G. Spillsbury	1845	1896	51	Grad.	Eurp.			×	×			
Wm. B. Potter	1846	1888	42	A.B.	Clmb.		×	×				×
Henry M. Howe	1848	1893	45	A.B.	Harv.		×	×			×	2
D. W. Brunton	1849	1909	60			×						
P. N. Moore	1849	1917	68	A.B.	Miam.		×				×	
Albert R. Ledoux	1852	1903	51	Educ.	Eurp.			×	×			

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS (*Continued*)

Name of President	Year of Birth	Year President	Age at Presidency	Degree or Graduation	College	No College Degree	Degree in Arts	Degree in Engineering	Graduate Engineering Study	Honorary Member	Society Medals	Honorary Degrees
C. W. H. Kirchhoff	1853	1898	45	Grad.	Eurp.			×				
E. E. Olcott	1854	1901	47	E.M.	Clmb.			×				
John Hays Hammond	1855	1907	52	Ph.B.	Shef.			×	×	×		4
James Gayley	1855	1904	49	M.E.	Laft.			×				2
Charles F. Rand	1856	1913	57			×						
Wm. L. Saunders	1856	1915	59	S.B.	U. Pa.			×				×
James Douglas	1858	1899	41	A.B.	Quen.		×			×	×	×
Edwin Ludlow	1858	1921	63	M.E.	Clmb.			×				
James F. Kemp	1859	1912	53	A.B.	Amht.		×	×		×		2
L. D. Ricketts	1859	1916	57	B.S.	Prin.			×	×			×
Benj. B. Thayer	1862	1914	52	C.E.	Lawr.			×				
Sidney J. Jennings	1863	1918	55	C.E.	Lawr.			×	×			
S. A. Taylor	1863	1926	63	C.E.	Ptbg.			×				×
Frederick W. Bradley	1863	1929	66			×						
Arthur S. Dwight	1864	1922	58	Grad.	Brkl.			×	×			
E. P. Mathewson	1864	1923	59	B.S.	McGl.			×				2
Horace V. Winchell	1865	1919	54	B.S.	Mich.			×				
J. V. W. Reynders	1866	1925	59	C.E.	Rens.			×				×
W. H. Bassett	1868	1930	62	S.B.	M. I. T.			×			×	
George Otis Smith	1871	1928	57	A.B.	Colby		×	×				2
Howard V. Eavenson	1873	1934	61	B.S.	Swth.			×				×
Herbert Hoover	1874	1920	46	A.B. in Eng.	Le. St.			×		3	4	27
Frederick M. Becket	1875	1933	58	B.S.	McGl.			×	×			
William Kelly	1877	1924	47	B.A.	Yale		×	×				2
Robert E. Tally	1877	1931	54	B.S.	Nvda.			×	×			
Scott Turner	1880	1932	52	A.B.	Mich.		×	×				
E. L. DeGolyer	1886	1927	41	A.B.	Min. Okla.		×					×

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Name of President	Year of Birth	Year President	Age at Presidency	Degree or Graduation	College	No College Degree	Degree in Arts	Degree in Engineering	Graduate Engineering Study	Honorary Member	Society Medals	Honorary Degrees
John Fritz	1822	1896	74			×				2		3
J. F. Holloway	1825	1885	60			×						
Coleman Sellers	1827	1886	59			×						×
Charles H. Loring	1828	1892	64			×						
Charles H. Morgan	1831	1900	69			×						
Edwin Reynolds	1831	1902	71			×						
John E. Sweet	1832	1884	52			×				×	×	×
George H. Babcock	1832	1887	55			×						
Horace See	1835	1888	53			×						
Charles E. Billings	1835	1895	60			×						
E. D. Leavitt	1836	1883	47			×				×		×

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (*Continued*)

Name of President	Year of Birth	Year President	Age at Presidency	Degree or Graduation	College	No College Degree	Degree in Arts	Degree in Engineering	Graduate Engineering Study	Honorary Member	Society Medals	Honorary Degrees
Robert W. Hunt	1838	1891	53			×				2	×	
R. H. Thurston	1839	1880	41	Ph.B.	Brwn.			×				2
Eckley B. Coxe	1839	1893	54	A.B.	U. Pa.		×	×				
Oberlin Smith	1840	1890	50			×						
John H. Brashear	1840	1915	75			×				×		6
Charles Wallace Hunt	1841	1898	57			×						
George W. Melville	1841	1899	58			×				×		3
E. D. Meier	1841	1911	70	Educ.	Eurp.	×				×		
Henry R. Towne	1844	1889	45			×				×		×
Worcester R. Warner	1846	1897	51			×				×		2
George Westinghouse	1846	1910	64			×				×	2	×
Ambrose Swasey	1846	1904	58			×				×	×	5
S. T. Wellman	1847	1901	54			×						
E. F. C. Davis	1847	1895	48	A.B.	Wsh. C.		×					
Jesse M. Smith	1848	1909	61	M.E.	Eurp.			×				
Alexander C. Humphreys	1851	1912	61	M.E.	Stev.			×				6
James M. Dodge	1852	1903	51			×						
M. L. Holman	1852	1908	56	A.B.	Wsh. U.		×					
Frederick R. Hutton	1853	1907	54	A.B.	Clmb.		×	×	×			3
John R. Freeman	1855	1905	50	S.B.	M. I. T.			×		2	4	5
Mortimer E. Cooley	1855	1919	64	Grad.	Anap.			×		×		4
F. W. Taylor	1856	1906	50	M.E.	Stev.			×				2
Ira N. Hollis	1856	1917	61	Grad.	Anap.			×		×		2
Charles T. Main	1856	1918	62	S.B.	M. I. T.			×				
Fred J. Miller	1859	1920	61			×				×		
W. F. M. Goss	1859	1913	54			×						×
W. F. Durand	1859	1925	66	Grad.	Anap.			×		×		2
Frederick R. Low	1860	1924	64			×				×		×
Elmer A. Sperry	1860	1929	69			×					2	3
James Hartness	1861	1914	53			×						×
W. L. Abbott	1861	1926	65	M.E.	Ills.			×		×		
D. S. Jacobus	1862	1916	54	M.E.	Stev.			×				×
Charles M. Schwab	1862	1927	65			×				×		8
Alex Dow	1862	1928	66			×						×
Dexter S. Kimball	1865	1922	57	A.B. in Eng.	Le. St.			×			×	4
Charles Piez	1866	1930	64	E.M.	Clmb.			×				×
John L. Harrington	1868	1923	55	S.B.	Kans.			×				
Paul Doty	1869	1934	65	M.E.	Stev.			×				
C. H. Lauer	1869	1922	63			×						×
Royden V. Wright	1876	1931	55	M.E.	Minn.			×				
Edwin S. Corman	1878	1921	43			×						
A. A. Potter	1882	1933	51	S.B.	M. I. T.			×				×

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Name of President	Year of Birth	Year President	Age at Presidency	Degree or Graduation	College	No College Degree	Degree in Arts	Degree in Engineering	Graduate Engineering Study	Honorary Member	Society Medals	Honorary Degrees
Norvin Green	1818	1884	66			×				×		
Wm. A. Anthony	1835	1890	55	Ph.B.	Shef.			×				
Franklin L. Pope	1840	1886	46			×						
Edwin J. Houston	1844	1893	49			×						×
Alexander G. Bell	1847	1891	44			×					2	7
Edmund Westin	1850	1888	38			×				×	×	3
Frank J. Sprague	1851	1892	41	Grad.	Anap.			×		×	×	3
Elihu Thomson	1853	1889	36			×				2	2	4
T. Comerford Martin	1856	1887	31			×						
M. I. Pupin	1858	1925	47	A.B.	Clmb.		×	×		×	2	6
Carl Hering	1860	1900	40	B.S.	U. Pa.			×	×			×
John W. Lieb	1860	1904	44	M.E.	Stev.			×			×	
Schuyler S. Wheeler	1860	1905	45			×						×
Francis B. Crocker	1861	1897	36	E.M.	Clmb.			×				×
A. E. Kennelly	1861	1888	27			×				×	2	3
Bion J. Arnold	1861	1903	42	B.S.	Hlsbro.			×	×		2	2
John J. Carty	1861	1915	54			×				×	2	9
C. O. Mailloux	1861	1913	52	E.E.	Brkl.			×	×			
Louis Duncan	1862	1895	33	Grad.	Anap.			×	×			
Samuel Sheldon	1862	1906	44	A.B.	Mdlby.		×	×				
E. W. Rice, Jr.	1862	1917	55			×				×	2	3
Lewis B. Stillwell	1863	1909	46	E.E.	Lehg.			×			×	2
C. C. Chesney	1863	1926	63	B.S.	Pa. St.			×			×	
Charles F. Scott	1864	1902	38	A.B.	Ohio		×			×	×	2
Calvert Townley	1864	1919	55	Ph.B.	Shef.			×	×			
Charles P. Steinmetz	1865	1901	36			×						×
Dugald C. Jackson	1865	1910	45	C.E.	Pa. St.			×	×			×
C. E. Skinner	1865	1931	66	M.E.	Ohio			×				
Harris J. Ryan	1866	1923	57	M.E.	Corn.			×			×	
Henry G. Stott	1866	1907	41			×						
Louis A. Ferguson	1867	1908	41	S.B.	M. I. T.			×				
Comfort A. Adams	1868	1918	50	S.B.	Case			×	×			×
Ralph D. Mershon	1868	1912	44	M.E.	Ohio			×				×
Harold B. Smith	1869	1929	60	M.E.	Corn.			×	×			2
Paul M. Lincoln	1870	1914	44	E.E.	Ohio			×				
Gano Dunn	1870	1911	41	B.S.	Cit.N.Y.			×	×		×	
William McClellan	1872	1921	49	B.S.	U. Pa.			×	×			
A. W. Beresford	1872	1920	48	B.S.	Brkl.			×	×			
William S. Lee	1872	1930	58	C.E.	Ctdl.			×				×
John B. Whitehead	1872	1933	61	E.E.	Jn. Hp.			×	×			
H. W. Buck	1873	1916	43	Ph.B.	Shef.			×	×			
Bancroft Gherardi	1873	1927	54	B.S.	Brkl.			×	×		×	
Farley Osgood	1874	1924	50			×						×
R. F. Schuchardt	1875	1928	53	E.E.	Wisc.			×				
Frank B. Jewett	1879	1922	43	A.B. in Eng.	Thrp.			×	×		×	8
H. P. Charlesworth	1882	1932	50	S.B.	M. I. T.			×				
J. Allen Johnson	1882	1934	52	B.S.	Worc.			×				

RECORD OF ARTS PLUS ENGINEERING DEGREES

Name of President	Year of Birth	Degree or Graduation	College	Later Degree if Any	College or Country
Thomas Egleston	1832	A.B.	Yale	Grad.	Eurp.
Alphonse Fteley	1837	Grad.	Eurp.	Grad.	Eurp.
Eckley B. Coxe	1839	A.B.	U. Pa.	Educ.	Eurp.
Mining and Metal. Engineering:					
Wm. B. Potter	1846	A.B.	Clmb.	E.M.	Clmb.
Henry M. Howe	1848	A.B.	Harv.	S.B.	M. I. T.
James F. Kemp	1859	A.B.	Amhs.	E.M.	Clmb.
George Otis Smith	1871	A.B.	Colby.	Ph.D.	Jn. Hp.
William Kelly	1877	A.B.	Yale	E.M.	Clmb.
Scott Turner	1880	A.B.	Mich.	E.M.	Mch. Mi.
Mechanical Engineering:					
Frederick R. Hutton	1855	A.B.	Clmb.	E.M.	Clmb.
				Ph.D.	Clmb.
Electrical Engrineering:					
M. I. Pupin	1858	A.B.	Clmb.	Ph.D.	Eurp.
Samuel Sheldon	1862	A.B.	Mdby.	Ph.D.	Eurp.

RECORD OF ENGINEERING DEGREES PLUS GRADUATE ENGINEERING STUDY

Name of President	Year of Birth	Degree or Graduation	College	Later Degree if Any	College or Country
Richard P. Rothwell	1837	Grad.	Rens.	4 yr.	Eurp.
R. W. Raymond	1840	Grad.	Rens.	—	Eurp.
Clemens Herschel	1842	S.B.	Lawr.	—	Eurp.
Civil Engineering:					
George F. Swain	1857	S.B.	M. I. T.	3 yr.	Eurp.
Charles D. Marx	1857	B.C.E.	Corn.	C.E.	Eurp.
Arthur N. Talbot	1857	B.S.	Ills.	C.E.	Ills.
Mining and Metal. Engineering:					
E. G. Spillsbury	1845	Grad.	Eurp.	—	Eurp.
Albert R. Ledoux	1852	Educ.	Eurp.	Ph.D.	Eurp.
John Hays Hammond	1855	Ph.B.	Shef.	—	Eurp.
L. D. Ricketts	1859	B.S.	Prin.	Sc.D.	Prin.
Sidney J. Jennings	1863	C.E.	Lawr.	—	Cali.
Arthur S. Dwight	1864	Grad.	Brkl.	E.M.	Clmb.
Frederick M. Becket	1875	B.S.	McGl.	—	Clmb.
Robert E. Tally	1877	B.S.	Nvda.	M.E.	Nvda.
Electrical Engineering:					
Carl Hering	1860	B.S.	U. Pa.	—	Eurp.
Bion J. Arnold	1861	B.S.	Hlsbro.	M.S.	Hlsb.
				—	Corn.
C. O. Mailloux	1861	E.E.	Brkl.	—	Clmb.
Louis Duncan	1862	Grad.	Anap.	Ph.D.	Jn. Hp.
Calvert Townley	1864	Ph.B.	Shef.	M.E.	Shef.
Dugald C. Jackson	1865	C.E.	Pa. St.	2 yr.	Corn.
Comfort A. Adams	1868	S.B.	Case	2 yr.	Harv.
Harold B. Smith	1869	M.E.	Corn.	2 yr.	Corn.
Gano Dunn	1870	B.S.	Ct. N.Y.	E.E.	Clmb.
William McClellan	1872	B.S.	U. Pa.	Ph.D.	U. Pa.
A. W. Beresford	1872	B.S.	Brkl.	M.E.	Corn.
John P. Whitehead	1872	E.E.	Jn. Hp.	Ph.D.	Jn. Hp.
H. W. Buck	1873	Ph.B.	Shef.	E.E.	Clmb.
Bancroft Gherardi	1873	B.S.	Brkl.	M.E.	Corn.
				M.M.E.	Corn.
Frank B. Jewett	1879	A.B. in Eng.	Thrp.	Ph.D.	Chic.

A STUDY OF THE PERFORMANCE OF FRESHMAN ENGINEERING STUDENTS IN THE LIGHT OF PREDICTION BASED UPON THEIR HIGH SCHOOL AND PLACEMENT TEST RECORDS

By E. R. WILCOX

Associate Professor of General Engineering, University of Washington

One might be tempted to say that "the woods are full" of placement test studies, high school grade studies, college grade studies and studies of their inter-relationships. Having said it one might be expected to remain quiet or else to challenge the desirability of adding further to "the population of the woods." However, in these days of intensive study of all means of improving the species, any pertinent observations on improved methods of selection should merit consideration.

In a recent paper Dr. August Dvorak and Mr. Rufus Salyer, of the Department of Education of the University of Washington, have outlined a method of procedure which they developed for predicting the probable scholastic success of engineering freshmen.[1] Their procedure involved the multiple correlation of several groups of high school grades and relative standings in Iowa Placement Tests in Mathematics and Physics with the average grade points earned for the year by the entire 1928–29 entering class of engineering students. The number of cases included in the study was approximately 200. The regression equation developed gave a predicted error of estimate of 0.28 grade points on a four point scale ($A=4$, $B=3$, $C=2$, $D=1$, $E=0$).[2]

The reliability of the predicted performance of students from this study seemed sufficiently good to warrant checking the results when applied to the class of engineering students who entered school at the beginning of the autumn quarter of 1931. Complete records were readily available at the beginning of the quarter for 163 students, or 58 per cent of the entire class, and these records were continued throughout the year. 150 or 92 per cent of this group finished their second quarter in Engineering in March, and 122 or

[1] Journal of Engineering Education, Apr., 1933, p. 618.

[2] G. P. A. as here used means the grade point average, or the sum of the credit hours earned multiplied by the numerical value of each credit grade, divided by the total registered hours. In this study credits in Military Science and Physical Education were disregarded.

74.8 per cent of them finished their third quarter in June, 1932. Some of the results and conclusions from the study of this group are here presented.

A. 1. Of the entire group studied, 68 men or 41.7 per cent did unsatisfactory work (made less than 2.00 G. P. A.) * during one or more of the first three quarters. See Fig. 1.

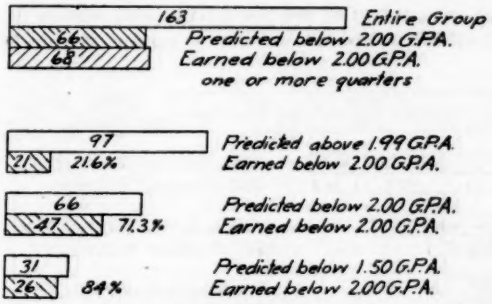

FIG. 1. Comparison of unsatisfactory performance in predicted groups.

2. During the same period 22 of these 68 men were dropped from school for poor work—13.5 per cent of the entire group studied.

B. 1. Of the entire group studied, 66 men or 40.5 per cent were predicted to have a G. P. A. of 1.99 or less. See Fig. 1.

2. During the first three quarters, 47 of these 66 men or 71.3 per cent actually made less than a 2.00 G. P. A. for one or more quarters and 18 or 27.4 per cent were dropped for poor work.

C. 1. Of the entire group studied 97 men or 59.3 per cent were predicted to have a G. P. A. above 1.99.

2. During the first three quarters, 21 of these 97 men or 21.7 per cent actually made less than a 2.00 G. P. A. for one or more of the quarters, but only 8 men or less than 10 per cent of the 83 of the group who finished the three successive quarters made less than a 2.00 G. P. A. for the year's work, and only 4 or 4.1 per cent were dropped from school for poor work.

This summary of the prediction and performance of unsatisfactory work in the groups is startling. This is so particularly when we take into account that a large amount of personnel work was done by the staff of the General Engineering Department, especially with those whose predicted G. P. A. was low. Some were advised to carry less than the normal schedule, some were

advised to take review courses in their high school mathematics, some were advised to drop courses in which they had but little chance to secure a passing grade, and others were advised to repeat courses in which they earned only a D grade, and still others were advised not to continue in engineering. All this, of course, tended to lessen the agreement between prediction and performance, but it did materially help the student in many cases.

A visual comparison of the persistence and success of the entire group and of three separate predicted groups is shown in Fig 2.

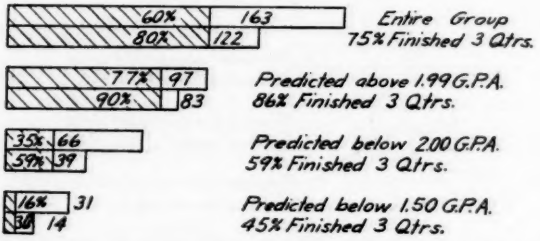

FIG. 2. Comparison of persistence and success in predicted groups. Percentage figure in shaded portion indicates proportion who finished 3 quarters with G. P. A. of 2.00 or better.

This comparison is perhaps even more striking than the previous one. Here we note that the man in the group predicted for C grades or better has more than nine chances in twelve of finishing his first year with a C average or better, whereas the man in the group predicted for D+ grades or worse has only two chances in twelve of finishing his first year with a C average. No man in this latter group made over a C+ average for the year and only one man made that high an average. As a matter of interest all five of this lowest predicted group who finished their first year with a C average returned for the beginning of their sophomore year.

The following table shows the results of a statistical study of the correlation between the predicted grades and the grades actually received during the first quarter and later quarters. It shows further the correlation between the grades received one quarter and the grades received the following quarter, and still further the correlation between an average of predicted grades and first quarter grades with subsequent grade averages. It is interesting to note that the predicted grades have as high a correlation with the first quarter grades as the first quarter grades have with the second quarter grades and practically as high as the second quarter grades have with the third quarter grades. The last corre-

CORRELATION BETWEEN PREDICTION AND PERFORMANCE

No. of Cases	Prediction	with Performance	Correlation Coefficient, "r"
157	Predicted Grades	1st Qtr. Grades	0.678±0.029
150	" "	Ave. of 1st and 2d Qtr. Grades	0.660±0.031
119	" "	Ave. of 1st, 2d and 3d Qtr. Grades	0.591±0.040
150	Ave. 1st Qtr. Grades	Ave. 2d Qtr. Grades	0.662±0.031
121	Ave. 2d Qtr. Grades	Ave. 3d Qtr. Grades	0.700±0.030
121	Ave. of Predicted Grades plus 1st Qtr. Ave.	Ave. of 2d and 3d Qtr. Grades	0.705±0.030
121	Ave. of Predicted Grades plus 1st Qtr. Grades	Ave. of 1st, 2d and 3d Qtr. Grades	0.814±0.021

lation coefficient in the table is higher than the others, of course, because the same item appears as a part of both variables but it gives a good idea of the reliability that is obtainable in predicting the year's scholastic performance at the end of the first quarter.

A critical remark to make at this point is that this is all very interesting but what of it? A reply can be made both in terms of money and of human value. It costs the state real money to supply four years of educational opportunity to a boy who thinks he wants to prepare for the profession of engineering or who thinks that a technical education is the best general background and preparation for the life which he wishes to live. If a boy can be convinced by evidence and competent council during his first two or three quarters in school that his chances of completing an engineering course successfully are too small to make it worth the cost and time, the engineering college is saved the cost of an additional year or two of his instruction. This much additional time is often spent by the student in arriving at the same conclusion if he is dependent entirely upon his own experimental evidence. Of course, this additional time is not all profitless but it probably could have been spent much more effectively in some other direction. From the standpoint of the student the sooner he can make his readjustment, if he is not well fitted for pursuing an engineering course, the better it is for him both financially and psychologically. The effect of discouragement from having gone in the wrong direction is much intensified, in many cases at least, with the increase in time consumed in going. But perhaps these ideas are so well accepted already that continuing further is not warranted.

Until some such scheme as Dean Ayer's idealistic dream * be-

* JOURNAL OF ENGINEERING EDUCATION, February, 1933.

comes more than a dream a large share of the responsibility for adjusting students into or out of engineering courses is going to continue to rest upon the engineering college. The more facts relating to the performance of its students which the college can establish and the more efficient procedure which it can build based upon these facts, the better it will be able to perform its duty toward the engineering freshman and the engineering profession as a whole.

CHEMICAL ENGINEERING LABORATORY TEXTS AND NOTE BOOKS *

By S. C. OGBURN, Jr.

Professor of Chemical Engineering, and Chairman, Division of Engineering, Bucknell University

Experimental work accompanying academic instruction in Chemical Engineering has been rapid in its evolution, both as to methods of presentation, types of experiments performed and the note books and reports required. This indicates an appreciation of the vital need of such work, and it reflects, as well, the youthfulness of formal instruction in this field. Similar progress was made by the older engineering curricula in arriving at their present status of recognized standard procedures for laboratory work. This was particularly true of Electrical Engineering as it developed from the field of physics. While it is generally agreed that absolute standardization of laboratory problems in Chemical Engineering is neither desirable nor possible, it is the opinion of the author that—in view of the accepted method of presenting the subject built around the unit operations, the unit processes and accompanying studies in heat flow, fluid flow and the mechanics of diffusion—certain *minimum standards* should be established with respect to the nature and extent of the experimental problems given and the equipment best adapted to these ends. It shall be the purpose of this paper, however, to express no more opinions but rather give an account of the methods and objectives followed by the author in the experimental work given to *undergraduate* chemical engineering students.

At Bucknell University, the general objective for such instruction is to give as broad and as fundamental a program as possible without overemphasis with respect to selected topics in the field and without specialization in specific fields of chemical technology. Our curriculum, as well as our equipment and facilities are primarily designed to make the undergraduate student the benefactor, and not individual members of the staff nor a given industrial firm. The student is introduced to the field of unit operations in connection with the course in Industrial Chemistry given in the Junior year and in which Riegel's text is used. This is followed in the

* Presented at the Conference on Chemical Engineering Unit Operations Teaching held during the 42d annual meeting, S. P. E. E., Ithaca, N. Y., June 21, 1934.

summer between the Junior and Senior years with the course in Principles of Chemical Engineering, in which Badger and McCabe's text is used. The experimental work accompanying this course will be presently described. In the Senior year, first semester, is given the course in Chemical Engineering Practice which includes a study of chemical engineering economics, principles of cost estimation, plant location, materials of construction of particular significance to the chemical industries, the source and handling of raw materials, the selection of plant equipment, and process development. For a part of this work, Tyler's book on "Chemical Engineering Economics" is used; the rest of the material is covered by lectures by the instructor, assigned reading with reports, and the laboratory work to be described. The second semester includes a course in Chemical Plant Design and another in Industrial Stoichiometry. In the latter course, the quantitative study of chemical engineering theory (including the unit operations), and selected industrial calculations is made. Other required courses in chemical engineering are: Industrial Chemical Analysis; Metallurgy and Metallography; and, the thesis course—Principles of Industrial Chemical Research. Elective courses available in the department are: Applied Electrochemistry; Fuels and Furnaces and Chemical Engineering Seminar.

The topics experimentally covered in the Principles Course (Unit Operations) are: Flow of Fluids; Flow of Heat; Mechanical Disintegration of Solids; Mechanical Concentration of Solids; Dissolving and Aqueous Mixing; Filtration; Drying; Distillation and Crystallization; and, High Temperature Production and Thermoelectric Pyrometry. The work is performed in squads of three men, one of whom is designated as foreman. He is held responsible for the results of the experiment and for the distribution of the work among the squad members, as well as for the submission of the data obtained in the laboratory. These data are checked by the instructor *before* the report is written on the individual experiment performed. While no attempt is made to cover the field of unit operations, those which are treated are thoroughly presented as to the construction and operation of the equipment used, the laws upon which their design is based, the factors influencing their use and efficiency, and, the interpretation of the data and graphs obtained. Instead of using loose leaf directions for distribution to the student, a mimeographed laboratory manual has been prepared for their use. This has been developed over a period of eight years, and is constantly being revised and readapted to a wider range of problems as the equipment becomes available. However, it is our opinion, that in giving this work, a *certain minimum amount of semi-plant equipment must be used* in order to present more ef-

fectively the applications of the theory of chemical engineering as *actually practiced* in industrial operations. No apology is necessary for the experiments selected as it is felt that these probably constitute those most widely and frequently used by the chemical engineer. Two successive afternoons per week for the equivalent of one semester are given for the completion of this course. The laboratory periods are from three to four hours each. Each experiment is divided into parts illustrative of several important phases of the topic treated. They may be summarized as follows: Fluid Flow studies include the measurement of velocities of fluids by means of the Venturi meter and the Pitot tube, the relation between the pipe size and the pressure heads developed; and, the determination of surface friction exerted by a fluid as measured by Reynolds Apparatus. Heat Flow includes a comparative study of rates of heat transfer through copper, steel and aluminum pipes, and, a study of heat exchangers, with the determination of the overall coefficient, the liquid film coefficient and the thermal efficiency of the equipment used. Mechanical Disintegration of solids include crushing, grinding and pulverizing problems pertaining to crushing qualities of the materials handled, sieve analyses, wet *vs.* dry grinding and the relation between R. P. M. and time of crushing with respect to fineness obtained. Mechanical Concentration of Solids deals with the use of shaker tables, oil and water flotation, electrical precipitation, and the study of the laws upon which these operations are based. In the experiments on Dissolving and Aqueous Mixing, the effect of agitation, diffusion and temperature on the rate of solution is studied together with a study of emulsification. Filtration includes a study of the effect of filter aids in filtration processes, the determination of rates of filtration at constant pressure and at constant filtrate outflow as well as instruction in the construction and operation of both plate and frame presses and the Sweetland leaf type filter. Ultrafiltration studies, through the use of the "Stream-Line" type, on industrial colloids also is included under this topic. Drying includes the determination of drying rate curves, and the comparative efficiencies of atmospheric *vs.* vacuum drying. Distillation and crystallization includes simple distillation studies, vacuum distillation and factors influencing crystallization rates and grain size. It is our present plan to include studies in rectification and plate performance with the installation of a fractionating unit next year. High temperature production includes studies of gas and electric muffle furnaces and the arc furnace, pertaining to rates of heating and cooling, radiation losses and means of calibration of the thermoelectric pyrometer.

The problems for study in connection with the course in Chem-

ical Engineering Practice include those frequently facing the practicing engineer and were selected on the basis of completeness and breadth of material covered as well as the ease of reproduction, in the laboratory, of data used in connection with the work which may be directly translated in terms of operating units. The topics selected fall into two groups. The first deals with corrosion studies on materials used in the manufacture of processing equipment, water softening, sludge constants used in connection with filtration problems—and, the thermal efficiencies of dryers. The second deals entirely with small scale development problems. Each squad completes each of the first group experiments and *any two* of a selected list of development problems, which include the production of such commodities as baking powder, putty, paper pulp from wood, alumina from bauxite, soda ash from cryolite, toilet soap, lithopone pigment, and diethylaniline. These preparations, usually amounting to from 25 to 50 lbs. of finished product, are not ends in themselves, but are used as a means of obtaining sufficient information concerning the process conditions, equipment requirements, etc., as to allow the student to prepare cost estimates, construct process diagrams and flow sheets, select the proper equipment for large scale projection in terms of from 10 to 100 tons of finished material desired to be produced in the plant, and to study other problems related to the nature of the industry dealt with, problems of plant location peculiar to it and general considerations influencing the design of such a large scale plant. In the Chemical Plant Design course, following the next semester, detail plans for the production of *one* of these commodities on a plant scale are assigned. Layout, assembly and, in some instances, detail drawings are required.

In each of the laboratory manuals, immediately following the brief notes on procedure given and the references for the work, is placed a blank page for the data taken. A simple form for recording data is given here, and in the experiments requiring draft of curves, a sheet of coördinate paper is provided in the manual. Both the data sheet and the coördinate paper sheet are perforated and can be removed. Each squad member keeps the data taken and draws his rough curves, but those sheets from the manual of the foreman are required to be *submitted to the instructor at the completion of the experiment and before the report is written.* In this manner, less loss results from mislaid data. It also saves the necessity for providing separate note books aside from the outlines of the experiment, and the whole is permanently bound so as to assure the student that he has all the necessary information for writing his reports—all within the confines of a single book. As the instructor has received a record of the data taken as the work

was done, there is less temptation on the part of the student to be dishonest in the data and calculations submitted in the subsequent report turned in with each experiment. Also, in the front of the manual, is a complete schedule of time allotted to each squad for each week's work. This allows the student to ascertain at any time whether or not he is completing the work in the time allowed for any part of the work.

The general form of laboratory report required in either of the above listed courses is the same. The report for the small scale development problems, however, include additional information as previously indicated. The topics treated in the report, included in the order of presentation, are: General Topic of the Experiment, Sub-Title, Materials and Equipment Required, Theoretical Discussion of all pertinent phases of the problem (including derivations of formulae, analysis of factors controlling the conditions of operation, etc.), Procedure of Experimental Work, Data and Calculations, and Conclusions. On the report cover is included: the course number, experiment number, title of experiment, name, squad number and foreman for that experiment, date work performed, date report due, and space for corrections required, acceptance date, and grade received.

In all experimental work emphasis is laid on the quantitative study of the problem where this is possible. (By this I mean in all cases where the results which may be expected from the student group are conclusive enough to verify quantitative laws with sufficient accuracy to establish beyond doubt their completeness. Unfortunately, not all of our chemical engineering problems can be thus simply reduced.) In other cases the work is frankly qualitative, but stress is laid in comparative relationships established, and the understanding of the variables which control the problem at hand. In our opinion, sufficiently clear instructions should be given the student to enable him, after a normal period of survey study of the material in question, to start immediately upon the problem and not to depend upon watching others who might be just finishing the experiment, or upon graduate students or even upon the instructor. It is easy to give too detailed instructions—this is to be avoided—on the other hand it is probably easier to give too few instructions. In this case the student wastes too much of his time trying to fit in the objectives of the experiment with the possible conclusions which might be expected. As the student gets further along in his work, fewer instructions should be given. The graduate student should require relatively few detail instructions—only well directed suggestions. But for the student *entering upon the experimental work of his first course* in the subject, more can be accomplished by more specific directions. After he has seen

how such instructions are related to his problem, and what the limits of these should be, he will be in a better position to prepare his own directions for subsequent problems.

While the author realizes these methods may not be the best to be used in all cases, he has found them to be the best, among several studied, for the development of a well rounded program for experimental work for the undergraduate student. It is hoped that these facts may be discussed by you, and through the conclusions drawn from such conferences as this the field of chemical engineering education will profit. A keen analysis of our problems, followed by sympathetic understanding and mutual coöperation will advance the progress of our profession.*

* Following the discussion of this paper, the Conference voted to request the Chairman, Dr. F. C. Vilbrandt, to appoint a committee to make a study of laboratory material and methods used in teaching the unit operations and to report at the next meeting of the Society. Dr. Ogburn was appointed Chairman of this committee and he requests those interested in its work to communicate with him or some member of the committee.

TEACHING LOADS—THEIR MEASUREMENT AND CALCULATION

By LOWELL O. STEWART

Associate Professor of Civil Engineering, Iowa State College

This paper will deal with two phases of the question of teaching loads. The first, in Part 1, will describe the survey which has been carried on by the Engineering Division at Iowa State College during the last two years. The second phase, in Part 2, will propose a method for calculating departmental teaching loads, based upon the data which may be obtained by the survey of Part 1.

Most teaching load surveys set out to find the total number of hours that are spent by each instructor on his numerous duties and activities. This was true for the study of teaching loads in the Engineering Division at Iowa State College, as reported by M. P. Cleghorn in the Journal of Engineering Education for May 1930. In that survey, the results were based upon the returns from a questionnaire which was filled out by each instructor. He kept a daily record for the week, or made an estimate, as he chose. The data which related to teaching were separated from the other data and studied separately, with the result that a formula for teaching loads was finally evolved.

Part I. The Measurement of Teaching Loads at Iowa State College

The present study covers a more intensive survey of the portion which relates directly to teaching. It had for its immediate objective the determination of the time required for the teaching of a given subject. The data required were, for each course, the time required in preparation, the time in the classroom, the time for grading papers, and the time in conferences relating to the course.

Perhaps the ideal study would be that in which each instructor kept an actual time record of his work with a course for an entire quarter. In that way, the heavy as well as the light periods, examinations and special problems, would be shown. Such an extensive project is hardly practicable with a large and busy faculty.

The alternative which was chosen for the survey to be discussed here was to take a series of studies, each two weeks in length. These two-weeks studies, or samples, were taken at a different portion of each quarter, that is, the second and third week, two weeks

which included the mid-term examinations, the eighth and ninth week, etc., so that the composite results should represent the picture of a typical quarter. Four such "two-weeks" studies were made during the school year, 1931–32 and three were made during 1932–33.

Certain general definitions of policy were agreed upon in the beginning. The time required in preparation was construed to include special work on notes, problems, or experiments in preparation for later class work, by an instructor during a vacation. This time was then distributed over the period which it was designed to cover. For example, if an instructor spent, thus, 100 hours on some notes that there to be used for a certain course during 2 quarters, say 23 weeks, he would charge $\frac{100}{23}$ or 4.3 hours per week to preparation.

Likewise, the time spent by a graduate assistant in grading papers, or in the classroom, was charged to the course in the column under grading, or time in class.

The time in class was taken as the catalog time, and a class period was taken as one hour in length, because the interval of ten minutes between classes could not be used elsewhere. In instances where there were two instructors, or an instructor and an assistant, for one class the actual time put in by each was charged to the class. In this connection it should be kept in mind that the purpose of the survey was to find the total time required to teach a subject, and not the teaching load of an individual.

In certain types of courses, such as drawing, the instructor frequently has an opportunity to make double use of his time. During quiet periods in the classroom he is able to correct and grade drawings, thereby shortening the total time. Similarly, two or more drawing or shop courses may be taught together, because of small numbers in each, thus reducing the time in class.

Such situations were explained by special notations on the back of the data sheet. Then later studies of the original data could determine the final disposition.

Data sheets were arranged to carry the data for one week. Each instructor was asked to make the entries on the sheet promptly after the time was used, rather than to wait a while and then to rely on memory. This admonition is important in such a study where the *actual* time is required.

In accordance with this, each instructor noted on the standard data sheet, which was furnished him, the time which he spent daily: in preparation, in the classroom, in grading papers, and in conferences relating to the course. Time spent in activities which did not relate directly to teaching was not considered in this

study. In the case of duplicate sections of a course the instructors were asked to separate the preparation, that is, indicate the amount of additional preparation entailed by the second, or third, or more, sections of the same course, because in many instances, the amount of preparation does not increase in the same ratio as the number of duplicate sections increases. The data at this point were not fully satisfactory because the preparation for two or more sections was combined into one item by many instructors. This may have indicated that certain instructors required no more preparation for two or more sections of a course than they did for one section.

At the end of the two-weeks period the data sheets were turned in to the central office where the total time for the week that was spent by the instructor on each of the four activities, viz., in preparation, in class, in grading, and in conference, for a given course, was found by adding the daily items.

These totals for each course were then transferred to tabulation sheets. Each course had its own tabulation sheet. It was intended that each section of the course should appear separately in the tabulation. But, as noted before, some instructors who were teaching two or more sections of a given subject sometimes combined the data. This did not affect the averages because each section was counted.

The next step was that of finding the average time *per section* spent on each of the four activities. It seemed advisable to consider average conditions. Under such conditions the number of sections of a given subject that may be taught by one instructor may vary from one to three, or more. The time spent in preparation for three sections of that subject is, probably, less than three times that spent for one section. But it would not be fair to consider that the preparation by the instructor for one section of his subject would be sufficient for several others taught by him during the same quarter. Conditions are different with instructors and with courses. In this study all sections were given the same weight in calculating the averages.

The average was calculated for preparation, grading, and conferences, by dividing the sum of all of the items in each column by the number of sections that were reported, that is, total time per week divided by the number of sections gave the average time per week spent on each course in preparation, grading and conferences.

These averages for the four items, preparation, time in class, grading, and conferences were placed on a second tabulation sheet, which was arranged by departments and, in some instances, by types of courses in that department, that is, 3-hour recitations, 2 three-hour laboratories, etc.

The sum of these four items for each course, the average prepa-

ration, the time in class, the average grading, and the average conference time, all per section, gave the total time spent per week on the average section.

This total time per week spent on the average section of a course was then divided by the number of credit hours which the course carried. This quotient, the average time per week per credit hour, may be used in several ways. For example, it may be the basis for the calculations for departmental teaching loads, as described in the second portion of this paper. Or it may bring out disparities between similar courses, which may lead to revisions in methods and subject matter.

The three tables which are included herewith will serve to illustrate the procedure which was followed in this Teaching Load Survey.

The original data sheet, Fig. 1, is a copy of one which was turned in by a member of "A" department for the week ending April 17, 1932. All the data and headings seem clear so no further explanation will be offered.

The totals from the original data sheets were transferred to tabulation sheets, like Tabulation Sheet No. 1. Each horizontal line on one of these sheets represents one week's totals for one section of a certain course. The first column "Course Number" could be omitted in cases where one course was tabulated on a page if the course number were placed someplace in the heading. The same is true for the column headed "Credits."

On Tabulation Sheet No. 1 for course "A" 1 there were 27 section reports from the original data sheets. The data for two of these sections (marked with an asterisk *) appear on the Original Data Sheet, Fig. 1. The figures 2.82 for preparation, 2,05 for grading, and 0.58 for conferences, represent the average number of hours spent per week for each of those items for course "A" 1. The average number of students per section is shown, also.

FIG. 1

Time Study for Teaching Load Survey
Dept. "A" Week ending April 17, 1932

Course		Number			
Name	No.	Rec. Lec. Lab.	Cr.	Students	Quarters You Have Taught Course
From Catalog	1	3 Rec.	3	14	two
" "	1	3 Rec.	3	18	two
" "	2	4 Rec.	4	24	one
" "	3	4 Rec.	4	19	none

Course No.	Day	Preparation for Class		Time in Classroom		Time Correcting Papers		Time in Conferences re. Course	
		Hr.	Min.	Hr.	Min.	Hr.	Min.	Hr.	Min.
	M	1	10	1	0	0	20		
	T		30						
*	W			1	0				20
1	Th		50			1	20		
	F			1	0				
	S	1	10						
	Sun								
	Totals	3	40	3	00	1	40	0	20
	M			1	0	0	20		
	T	1	30						
*	W			1	0				
1	Th						40		
	F			1	0	1	0		
	S								
	Sun								
	Totals	1	30	3	00	2	00	0	00
	M	1	20	1	0	0	40		
	T			1	0	0	40		
	W	1	0						
2	Th	1	10	1	0	0	35		
	F			1	0				
	S	1	30			1	0		
	Sun	0	40						
	Totals	5	40	4	00	2	55	0	00
	M		30	1	0	0	40	0	25
	T	2	30			0	40		
	W	2	40	1	0			0	15
3	Th	2	30	1	0	0	35		
	F	1	30	1	0				
	S					1	0		
	Sun		30						
	Totals	10	10	4	00	2	55	0	40
	M								
	T								
	W								
	Th								
	F								
	S								
	Sun								

This is a copy of an original Data Sheet.

* These sections are on Tabulation Sheet No. 1.

Tabulation Sheet No. 1

Type of Course, Rec. Department "A" Date Jan. 16 & 23 Mar. 6 & 13 April 17 & 24 Nov. 14 & 21

Course Number	Number Hours in Class	Number Times Taught	Credits	Hours on Preparation per Week	Number Students	Hours Grading per week	Hours in Conference per Week
1	3	0	3	5.0	16	2.1	0.9
"	3	0	3	1.1	25	3.4	1.2
"	3	0	3	3.3	19	1.0	0.5
"	3	0	3	4.5	28	0.5	2.0
"	3	0	3	3.5	19	0.7	0.2
"	3	0	3	3.7	28	2.2	0.9
"	3	0	3	2.5	16	3.5	2.4
"	3	0	3	1.0	25	3.5	2.0
"	3	1	3	4.9	21	0.8	0.8
"	3	1	3	9.0	20	1.7	0.0
"	3	1	3	4.3	21	1.7	0.5
"	3	1	3	3.3	18	0.0	0.0
"	3	1	3	4.0	20	2.5	1.5
"	3	0	3	6.7	14	1.7	0.4
"	3	0	3	0.0	13	1.8	0.0
"	3	2	3	2.5	15	0.4	0.0
"	3	2	3	0.0	17	0.5	0.0
"	3	0	3	4.9	14	3.0	0.0
"	3	0	3	1.0	13	3.2	0.0
*"	3	2	3	3.7	14	1.7	0.3
*"	3	3	3	1.5	18	2.0	0.0
"	3	3	3	1.5	25	5.5	0.1
"	3	3	3	1.0	19	6.0	0.2
"	3	3	3	1.0	16	6.0	0.2
"	3	3	3	2.2	25	0.0	1.5
"	3	3	3	0.0	19	0.0	0.0
"	3	3	3	0.0	16	0.0	0.0
27 Sections			27)76.1	27)514		27)55.4	27)15.6
			Av. = 2.82	Av. = 19.0		Av. = 2.05	Av. = 0.58

* These two sections show on data sheet.

Tabulation Sheet No. 2 shows the averages for all of the courses of "A" department as calculated on sheets like Tabulation Sheet No. 1. Here, the course "A" 1, marked with an asterisk,* is the one for which the averages were calculated on Tabulation Sheet No. 1. These figures represent hours per week. The total number of hours is the sum of columns 2, 3, 4, and 5. For course "A" 1, this "total hours per week," 8.45 is found by adding 3.0, 2.82, 2.05 and 0.58. The "number of hours spend per credit" is found by dividing the total of column 6 by the number of credits in column 1. For course "A" 1, dividing 8.45 by 3 gives 2.82 as the number

Tabulation Sheet No. 2

TEACHING LOAD SURVEY
ANALYSIS SHEET
"A" DEPARTMENT

Total Number Sections	Course No. "A"	Credit	Hours in Class	Hours on Preparation	Hours in Grading	Hours in Conference	Total Hours 2+3+4+5+6	Hours Spent per Credit	Average Number of Students per Section	Desirable Number per Section
		1	2	3	4	5	6	6/1		
27*	1	3	3	2.82	2.05	0.58	8.45	2.82	19.2	20
35	2	5	5	3.22	3.88	1.16	13.26	2.65	18.9	20
32	3	4	4	4.00	2.59	0.74	11.33	2.82	20.0	20
18	4	4	4	5.62	2.48	0.42	12.52	3.13	18.7	20
3	5	3	3	6.80	0.33	0.57	10.70	3.90	6	10

* This is the course shown on Tabulation Sheet No. 1. Hours are per week.

of hours per credit. The figures in this column "Hours spent per credit" represent hours per week per credit.

The last two columns are used for purposes of comparison and reference. The first of the two shows the average number in the classes. The last shows the number which is considered by "A" department to be the desirable size for effective teaching.

A comparison of the results of the surveys of the two years shows some very good correlations on the item "Hours spent per credit." Those that agreed closely seem to be courses where the subject matter and the teaching methods may receive uniform treatment. There were some courses where the difference between the two years was rather large. The following table shows the results for each year on courses for which there were at least six sections reported.

PART 2. THE CALCULATION OF TEACHING LOADS

The question of teaching loads is a perennial one. In fact, during a period of diminishing budgets and lighter enrollments the whole matter of instructor-student ratios is subjected to a critical examination to find places for possible financial economies. The administrator who is faced with the necessity of reducing his teaching staff faces a dilemma: he must decide where to make his reduction in personnel, and after that has been done, how to distribute the load amongst the remaining members of his department. In most instances these re-arrangements have been based upon the best judgment of the individual department heads or deans and have been made, equitably, no doubt, within a homogeneous group. But when the results in various groups are compared, it is evident that there are likely to be wide differences, both in the method used and in the final distribution of the teaching loads.

COMPARISON OF RESULTS TWO YEARS SURVEY IOWA STATE COLLEGE

Course No.	No. Credits	Year	Number Sections Reported	Hours per Week per Credit	Remarks
B1	1	1931–32 = a 1932–33 = b	31 32	6.1 6.4	
B2	1	a b	40 8	7.0 6.6	
B3	1	a b	9 16	8.6 6.5	Course revised, second year
B4	1	a b	27 28	6.4 7.2	
A4	5	a b	35 25	2.6 2.7	
A3	4	a b	18 9	3.1 2.8	
A2	4	a b	32 14	2.8 3.1	
A1	3	a b	27 27	2.8 2.8	
C1	3	a b	7 9	1.8 1.1	
C2	2	a b	24 26	2.4 3.6	
C3	2	a b	32 10	3.6 4.1	
C4	2	a b	30 22	3.2 3.3	
C5	2	a b	28 36	4.4 3.4	
C6	1	a b	6 10	4.6 5.1	

COMPARISON OF RESULTS TWO YEARS SURVEY IOWA STATE COLLEGE (*Continued*)

Course No.	No. Credits	Year	Number Sections Reported	Hours per Week per Credit	Remarks
C7	1	1931–32 = a 1932–33 = b	20 28	5.5 5.1	
C8	1	a b	24 22	4.1 4.3	
C9	1	a b	48 50	4.9 5.4	
B5	3	a b	12 23	2.3 2.2	
C10	1	a b	12 18	3.6 3.5	
C11	1	a b	25 18	3.6 3.5	
D1	3	a b	7 9	2.0 2.0	
D2	3	a b	8 11	2.8 2.8	
D3	3	a b	8 10	2.4 2.1	
D4	3	a b	12 17	2.2 2.2	
D5	2	a b	6 8	3.9 5.0	
E1	4	a b	6 6	2.9 2.7	
F1	2	a b	23 13	4.9 4.2	

Therein lies the most perplexing aspect of the whole matter of teaching loads. Courses within a department differ from each other in their demands on the instructor's time. Likewise they differ from the courses of other departments, sometimes to a greater degree, sometimes to a lesser degree, than the difference within the department. Taking the average of all these figures it is probable that one arbitrary unit, such as the well known student-credit hour ratio, may be used to calculate the teaching load, and from that the required number of instructors, for an entire college or university. The true number, which may agree finally with this figure arrived at in such a simple manner, must actually be determined by adding together the numbers of instructors that are required by the various departments that make up the institution. These departments can rarely use so simple a ratio, and certainly not the average ratio, in calculating their teaching loads and the number of instructors required.

This paper proposes an answer to the problem, and a method for calculating teaching loads that is simple and direct because it deals with figures that are interpreted readily, and that have the same meaning to every one. It considers the load of a department, rather than that of the individual instructor, as the unit upon which calculations are based.

It depends upon the following factors:

(*a*) The number of hours per week to be spent by each (the average) instructor on work relating directly to classroom teaching. This figure will be set by the administrative officer, probably the Dean, after a study of conditions within his division or college. The total load which must be carried by the teaching staff includes many activities besides teaching. These are legitimate and should be reckoned as a part of that total.

This involves, of course, an acceptance of the idea that a definite number of clock hours can be specified as a normal week's work. Educators have seemed reluctant to do this in plain figures that could be understood and used. They have done it indirectly, and oftentimes inequitably, when they have set a teaching load as a certain number of credit hours per week. Once the normal week's load in clock hours has been set it is possible to indicate the number of clock hours that are to be devoted to work relating directly to teaching, that is, preparation for the class, in the classroom, grading papers, and in conferences relating to the course.

(*b*) The maximum and minimum size of section. Thus far no satisfactory scientifically objective method has been found for determining the maximum size of a section, up to which size teaching effectiveness will not be weakened. Lacking such a criterion, the figure for maximum effective size for each subject should be estab-

lished by those who are experienced in the teaching of that subject. Where room space and equipment are limited, they, rather than the size for effective teaching, may be the determining factor in fixing the maximum number.

The minimum permissible size of section must be known also. In many cases this figure will have to be set arbitrarily by an administrative officer, usually the president. There is no doubt that the indiscriminate tolerance of small sections tends to raise teaching costs substantially. On the other hand their ruthless and indiscriminate removal may cause much inconvenience, and actually reduce the effectiveness of the institution.

(*c*) The total time required to teach a section of a given subject. These data should come from a teaching load survey like that conducted by the Engineering Division at Iowa State College and described in Part I of this paper. It consists of time spent in preparation for class, in the classroom, grading papers, and in conferences relating to the course.

Size of section, the number of sections taught during the quarter, and experience in teaching the course are important determinants of the total time. For example, size of section (number of students in the section), has much to do with determining the total number of hours spent by the instructor on a problems course, and comparatively little with a lecture course. In the problems course, the work of grading increases directly as the number of students increases, while the work of preparation for a lecture is quite unrelated to the number of students in the section.

On the other hand, duplication of sections may have a large effect upon the total time in a recitation course by affecting the preparation, and somewhat less in a problems course where grading papers is a heavy item. Conditions vary with courses and with instructors. In general, however, an instructor who spends X hours in preparation for one section of a course will not spend 2X hours or 3X hours for two sections or 3 sections of that course. Further studies, involving a comparison of reports with and without duplicate courses, are needed to establish this difference.

The total time for any course may be corrected for an increase or decrease in numbers by applying the increment or decrement due to numbers which appears in the grading of papers, and in conference. The figures showing "hours grading per week" and "hours conference per week" in Tabulation Sheet No. 1 of Part 1 are dependent upon a definite number of students per section. When making an estimate of time for these items on any trial section, the difference in numbers between the base section and trial section should be considered. Probably the time varies directly with the number in the section. Under normal conditions, how-

ever, the average sizes of sections will remain uniform and no attention need be given to small differences.

In addition to the study relating only to time concerned with teaching there should be a second study which would show the total time of any department which is given to what may be called "extra-curricular" activities. The extent of these activities should be determined by an actual time study similar to that conducted for the work relating directly to teaching. The technique for carrying on the latter study would be similar to that for the first, namely, an actual day by day record kept by each man over a reasonable length of time, say two weeks.

There is an overlapping of the items in these two studies. In fact it is in the realm of this work, classified here as "extra-curricular," that there is danger of over-loading both actual and implied. Under this heading there are included, frequently, such items as executive and office work; committee and faculty meetings; conferences (not relating directly to a particular course); research; professional improvement, including therein, attendance at and participation in the meetings of technical and professional societies, writing books and papers, general reading to keep abreast of the times; services as a consultant; participation in student activities; and many others.

All of the foregoing items are important and necessary in the makeup of the composite duties of the average member of a college faculty. The extent to which they should be included, both individually and collectively, in measuring the total "load" of an instructor is not so clear. If a large number of such items are included as a part of the load, then the normal weekly load for each instructor must be high. If, on the other hand, some items are recognized as a part of the personal schedule of a normal instructor, the "work-week" may be set at a lower figure. Some of the most perplexing problems of load distribution lie in this field.

Perhaps the simplest way to handle the problem would be to choose a number of hours per week which must be spent by the average instructor on work relating directly to teaching, that is, time spent in preparation for the class, time in the classroom, grading papers, and in conferences relating directly to the course. Preparation for the class would include work of the instructors in connection with the set-up of certain laboratory experiments, such as those in electrical or mechanical engineering. This time could be charged in the proper ratio to the various courses involved, or, handled as a separate item.

Actually, the intelligent selection of the number of hours which the average instructor should spend on work relating directly to teaching requires a thorough knowledge of the local conditions.

Departments and divisions are likely to differ widely in their "extra curricular" demands upon their faculties.

The following factors, previously discussed will be used in these calculations:

1. The maximum size of section: as given for each course in the table.
2. The minimum size of section: 10 students.
3. The number of hours to be given per week by the average instructor to work relating directly to teaching will be taken as 36. This includes as stated before: time in preparation for the class, time in the classroom, grading papers, and conferences relating directly to the course. All other activities are in addition to the 36 hours.
4. The total number of hours in the "Total Work-Week" of the average instructor will be taken as 44. This includes the 36 hours in (3) plus 8 additional hours for "extra-curricular" activities.

In the Table for Calculation of Teaching Load, Column 1 identifies the courses by the official catalog numbers. Column 2 gives the number of students enrolled in each course. Column 3 represents the judgment of those who, presumably, are best able to set such a figure. Some tolerance must be allowed for each of these "Maximum Number for Effective Teaching" when making the calculation for the "Desirable Number of Sections" in Column 4. The latter column is found by dividing column 2 by column 3, and using the nearest whole number that fits the quotient, keeping in mind the permissible minimum size of section, and the number by which the maximum may be exceeded, if at all; Column 5 gives the number of credits, semester or quarter, as stated in the catalog.

Column 6 gives the average number of hours per week per credit that are required to teach each course. This figure is obtained from the teaching load survey described in Part 1. Column 7, the "Calculated Total Instructor-Hours," is the product of columns 4, 5 and 6, and represents the total number of hours per week that are required for the teaching of all sections of a given subject. Incidentally, columns 5 and 6 could be combined to make "Total Time per Week per Section." The "Hours per Week per Credit" is useful, however, for comparing the teaching time requirements of different courses.

In calculating column 4, the "Desirable Number of Sections," there must be some leeway in the size of the sections. For example, in course Number 2 should the number of sections be 2, making the size of section 10; or the number of sections 1, making the size of section 20? Likewise, in course Number 7, should there be 2 sections with 19 in each section, or 3 sections with 13 in two sections,

and 12 in another? In course Number 10 should there be 4 sections averaging about 18 per section, or 3 sections averaging 24 per section?

It is usually difficult or impossible under the practical exigencies of most classification situations to strike the ideal balance in the size of sections. This fact should be kept in mind when answering the questions raised in the preceding paragraph. For example, using 3 sections for course Number 10 might result in 2 sections having 27 each, with one section having 19. Sometimes redistributions can be made in such cases—often resulting in "unbalances" elsewhere. The final answer should depend upon the "tolerance" that can be permitted in the size of section. Such "tolerances," which are, after all, matters of judgment, are likely to vary as the enrollment varies.

Certain other adjustments may be made by a department head in arranging his teaching load. For example, small groups in related courses like drawing, shop, surveying, may be combined to make a single section. Or, the indicated time may be reduced by taking cognizance of the fact that, in certain courses, the in-

TABLE FOR CALCULATION OF TEACHING LOAD
"X" Department

Course Number (1)	Number of Students Classified (2)	Maximum Number for Effective Teaching (3)	Desirable Number of Sections (4)	Credits (5)	Hours per Week per Credit (6)	Calculated Total Instructor-Hours (7) (4)×(5)×(6)
1	55	25	2	3	2.2	13.2
2	20	15	1	3	3.8	11.4
3	121	20	6	3	2.2	39.6
4	51	15	3	3	3.8	34.2
5	56	20	3	3	2.8	25.2
6	59	20	3	3	2.5	22.5
7	38	15	3	4	2.5	30.0
8	8	Graduate Course	1	4	4.6	18.4
9	8	Graduate Course	1	5	3.8	19.0
10	73	20	4	1	4.3	17.2
11	51	12	4	1	6.6	26.4
12	50	10	5	1	7.7	38.5
13	53	8	6	1	5.9	35.4
14	38	12	3	2	4.6	27.6

Total instructor hours per week.....358.6 hours
Total hours per week for "extra curricular" activities.....100.0 "
(This would be determined from another study)
Total "work week" for "X" Department.....459 "

structor may do two things at one time, such as grade papers during a drawing period. All of this would be indicated in the calculations.

The next and final step is to find the number of instructors that will be needed by "X" department to do the work indicated in the Table for Calculation of Teaching Load. This may be done on the basis of (*a*) The Total Work Week, or (*b*) The Teaching Week. (*a*) To find the number of instructors required on the basis of the "Total Work Week," divide the "Total Work Week" for "X" Department, 459 hours, by "Total Work Week" per Instructor, 44 hours. This gives 10.4+ instructors. (*b*) To find the number of instructors required on the basis of the "Teaching Week," divide the "Total Instructor Hours per Week" for "X" department, 359 hours, by the Instructor Teaching Week, 36 hours. This gives 10.0 instructors.

Under the method just described, each department becomes the unit upon which the calculations are based. No attention is given to individual teaching loads. That would be the task of each department head who would distribute the work amongst the members of his departmental faculty.

TECHNICAL SYSTEM OF DIMENSIONAL UNITS

By F. A. BROOKS

Associate Professor of Agricultural Engineering, University of California

When an engineer in one scientific field attempts to make use of technical information published in another field, he encounters specialized usage of common symbols and dimensional units that are rarely defined in a manner sufficiently exact for confident application to the problem in hand. Dimensional analysis is, of course, the first step in deciphering such data but this approach is not satisfactory when one is confronted by frequent ambiguous usage of common terms.

The dual interpretation of *density* is evidently the predominant cause of dimensional conflict. The Smithsonian Physical Tables (8th Rev. Ed., 1933, p. xxxiv) defines *density* as the quantity of matter per unit volume $[ML^{-3}]$ and then gives an example in pounds per cubic foot—obviously a weight density, not a mass density. Similarly, the Handbook of Chemistry and Physics (18th Ed., 1933, p. 1640) gives density the dimensions $[ml^{-3}]$ but under this heading gives the standard density of mercury as 13.5951 grams per cubic centimeter, which must be a weight density to satisfy the subsequent definition of *pressure*.

The English specification of *viscosity* is another flagrant example of dimensional misuse. In the new Chemical Engineers Handbook (1934, p. 698) this is given dimensions [(lb.)/(sec.) (ft.)] where (lb.) must be interpreted as a weight to conform with a weight density used for kinematic viscosity. This, of course, is incorrect in spite of general engineering usage and leads to a distorted English absolute viscosity which with the usual conversion of $0.0672 \times$ poise gives a viscosity 32.174 times the true value.

The conflicts cited are basic dimensional errors not in the category of the specialized usage of inches together with feet, or seconds with minutes and hours which are questions only of units of the same dimensions. The conception of density as a weight per unit volume is almost universal in engineering, chemical and thermodynamic literature in spite of its exact physical definition as mass per unit volume. In the metric system a gram is defined dually as either the weight or mass of 1 cc. of water. The dyne is specifically a unit of force. In the English system a pound is used indiscriminately for weight, mass and force, though the predominant usage

of pound is for weight and force because practical calculations involving the dynamic effects of mass are relatively rare in comparison with daily problems of weight, stress, load, etc.

Instead of trying to correct common usage to an arbitrary physical definition it is obviously expedient and also theoretically correct to develop the usage of the technical or "Engineers" dimensional system based on the fundamental dimensions of force, length and time [*FLT*]. In this system force or weight is predominant and mass is secondary. It is unfortunate that texts such as P. W. Bridgman's "Dimensional Analysis" are written in terms of mass-length-time [*MLT*], because mass does not appear in the definitions of the most common physical terms such as Force, Work, Power, Impulse, Unit Stress, Etc., and consequently $[MLT^{-2}]$, $[ML^2T^{-2}]$, $[ML^2T^{-3}]$, $[MLT^{-1}]$, $[ML^{-1}T^{-2}]$, connote nothing of our usual interpretations of these quantities. In striking contrast, the clearness and convenience of the technical system for dimensional analysis is obvious in O. Tietjens, "Applied Hydro- and Aeromechanics" (1934, p. 9–13).

The available lists of quantities with dimensions given in terms of [FLT] are brief * and have not received the attention they deserved. The following table is offered to encourage strict dimensional usage in accord with customary engineering usage of physical terms. The only change implied is that *density* be recognized as meaning a weight density and that wherever *mass* or *mass density* is meant, the word "mass" must be specified. Mass should always be thought of as weight divided by the acceleration of gravity.

There is no need to question whether *force* is as fundamental as *mass*. In the theory of dimensions *fundamental* is a relative term applied to any discrete physical quantity and does not mean a fundamental physical quantity. *Energy* is the most fundamental quantity extending through all fields of physical science but it is unsuitable for use as a fundamental dimension because in general, energy is not observed directly and therefore rarely appears in the definition of other physical quantities. For instance, it is difficult to vizualize *Force* as *Energy* divided by *Length* although *Pressure* as *Energy* per cubic *Length* does not seem so strange. Weber † points out that *Energy* was proposed as a fundamental dimension by W. Ostwald without much success in 1891.

Possibly the most telling argument against dimensional analysis is that ordinarily the dimensional expressions for work and torque are identical. This difficulty can be avoided by following

* O'Rourke, 1932, "General Engineering Handbook," p. 87.

† Weber, Ernst, "A Proposal to Abolish the Absolute Electric Unit Systems," *Trans. A. I. E. E.*, Vol. 51, No. 4, Sept., 1932.

TABLE OF TECHNICAL SYSTEM DIMENSIONS (F, L, t)

Concept	Dimension
Angular Distance (radians)	LiL^{-1}
LENGTH	L
Head	L
Hydraulic Radius	L
Work per Unit Weight	L
Twist, Rotary Power	$(\theta)L^{-1}$
Coefficient of Absorption	L^{-1}
Area	L^2
Volume	L^3
Section Modulus	L^3
Moment of Inertia (area)	L^4
Polar Moment of Inertia (area)	L^4
TIME	t
Period (harmonic motion)	t
Frequency	t^{-1}
Revolutions per Unit Time	t^{-1}
Angular Velocity	$(\theta)t^{-1}$
Angular Acceleration	$(\theta)t^{-2}$
Velocity (linear)	Lt^{-1}
Acceleration (linear)	Lt^{-2}
Kinematic Viscosity	L^2t^{-1}
Diffusivity	L^2t^{-1}
Flow or Rate of Discharge	L^3t^{-1}
FORCE, Conc. Load, Total Stress	F
Weight, Total Load, Etc.	F
Impulse	Ft
Momentum	Ft

Concept	Dimension
Work	FL
Energy	FL
Energy of Rotation	$(\theta)^2FL$
Torque	FiL
Bending Moment	FiL
Spring Constant	FL^{-1}
Surface Tension	FiL^{-1}
Pressure (unit normal)	FiL^{-2}
Unit Stress (tensile or comp.)	FiL^{-2}
Resilience	FiL^{-2}
Young's Modulus of Elasticity	FiL^{-2}
Bulk Modulus of Elasticity	FiL^{-2}
Modulus of Rupture	FiL^{-2}
Unit Stress (shear)	FL^{-2}
Modulus of Rigidity	$(\theta)^{-1}FL^{-2}$
Elastic Constant	$F^{-1}L^2$
Specific Volume	$F^{-1}L^3$
Density (weight)	FL^{-3}
Density (mass)	$FL^{-4}t^2$
Mass (= weight/g)	$FL^{-1}t^2$
Inertia (mass)	$FL^{-1}t^2$
Polar Moment of Inertia (mass)	FLt^2
Angular Momentum (mass)	$(\theta)FLt$
Action (Planck's quantum)	FLt
Power	FLt^{-1}
Viscosity (absolute)	$FL^{-2}t$
Weight Velocity	$FL^{-2}t^{-1}$

Kennelly's * method of specifying *Torque* as *Force* perpendicular to *Length*. The vector notation i or j for $\sqrt{-1}$ gives a perfect means for expressing this relation. This is a special case of the

* Kennelly, A. E., April, 1930, "Magnetic Circuit Units," *Trans. A. I. E. E.*, Vol. 49, No. 2, p. 486.

non-dimensional Θ for angle needed to express angular velocity, acceleration, etc., which is measured in terms of length of arc and of radius which are perpendicular to each other. So if Θ is also interpreted as $\sqrt{-1}$ the Torque X Angular Motion calculations all yield real values. However, until this feature of dimensional theory is explored more thoroughly the notation j can be used most effectively as a simple warning of noncolinear relations.

In carrying the three fundamental dimensions of Force-Length-Time into the fields of Thermodynamics and Electricity, there is no question that Force is a better dimension than Mass. The electrical and magnetic systems of units present a very complicated problem although the practical units are well established and some could be used with Force, Length and Time to make a convenient dimensional system that would fit in with the mechanical and thermodynamic systems. However, the use of *Force* as a fundamental dimension in electrical engineering or in thermodynamics can not be expected before its acceptance in the mechanical fields. Increasing use of the FLT system is noticeable in hydraulics, but general adoption in the various applied physical sciences seems to wait upon a change in teaching.

REPORT OF CONFERENCE ON ENGLISH

The clinics of the English conference were concerned with the effectiveness, in college and after college, of English in its functional uses; with oral exposition, that much stressed phase of English about which so much has been said and so little has been done; and with literature courses upon which until the present time has been put in a large measure the cultural load in the engineering curricula. Indeed, literature courses have borne this load to such an extent that the question arises as to whether it is possible adequately to meet the functional demand of English by developing a "qualifying standard for composition," and thus release students for literature courses. In a joint session with the Division of Drawing the possibilities and the desirability of more definite cooperation between English and drawing were discussed.

These sessions brought together more English teachers in the technical schools than ever before, and the preliminary program interested still more who have expressed their desire for information,—a direct result of the group consciousness that has been growing since the summer session on English in 1932. The discussion was concrete, lively, fact-finding, constructive and critical. English teachers told what is being done in English courses in their particular institutions, and learned from engineers in active practice what are the permanent results of college English courses, and the place of English in professional development. The average attendance at the sessions was 25.

As a result of this conference, plans are being formulated by the Committee on English to function as an executive body, that is, each member will cultivate the acquaintance of the English teachers in the technical schools of the particular section of the country which each member of the Committee represents and offer opportunity for active participation in the Committee projects. Thus English teachers can extend their acquaintance with others with similar interests, keep themselves informed upon activities in English and other colleges, upon new texts, and upon timely discussion related to English that is available in the current professional publications. The Committee expect to make available a bibliography of the articles on English that have appeared in the *Proceedings* and the *Journal* of the Society. They hope to cooperate as far as practicable and desirable with the student division activities of professional societies, and to study among them-

selves the status of the English teachers of technical students, and at a special session of the English Conference in 1935 as a part of the Annual Meeting to consider policies and problems of English courses required and offered engineering students.

This first English Conference has, in the opinion of the Committee, been successful, stimulating, constructive, timely and forward looking. The greatest lack, arising to some extent from overloading the program with quality material, has been that there was so little opportunity at the time for extended consideration of the papers and their subsequent discussion.

S. A. HARBARGER,
Chairman.

COLLEGE NOTES

Armour Institute of Technology announces promotions and new appointments as follows:

Henry Townley Heald, formerly Dean of Freshmen, has been appointed Dean of the College.

John C. Penn is in charge of the Department of Civil Engineering.

Philip C. Huntly is in charge of the Department of Mechanical Engineering.

Charles E. Paul, Professor of Mechanics and in charge of that department and of the Department of Science, is also in charge of the Department of Mathematics.

W. E. Kelly, formerly Recorder, has been appointed Registrar.

Two new faculty members have been appointed in the Department of Chemical Engineering. Frank T. Barr is a graduate of Washington University and a Ph.D. of the University of Illinois. He has taught Chemical Engineering at both of these schools. F. A. VanAtta took his bachelor's degree at the University of Oregon and his doctor's degree at Northwestern University.

A newly appointed member of the faculty of the Mathematics Department is Rufus Oldenburger, who is a Ph.D. of the University of Chicago, and who has had teaching experience at the Case School of Applied Science and the University of Michigan.

In the Physics Department, Austin B. Sprague is a graduate of Miami University, with M.S. and Ph.D. degrees from Ohio State.

The Department of Mechanical Engineering has engaged C. E. Hammett, who is a graduate of Kansas State College and who received his master's degree at the University of Nebraska.

Charles O. Harris, newly appointed in the Department of Mechanics, received his bachelor's and master's degrees at the University of Illinois.

Hanns Fischer, the newly appointed instructor in French and German, is a graduate of the University of Munich.

Edward A. Merrill, of the Architectural Department, a graduate of Massachusetts Institute of Technology, is a practicing architect and structural engineer.

The personnel officer in charge of placement work is William N. Setterberg, a graduate of Armour of the Class of '29.

Armour has lost one of its most valued faculty members by the death of Professor Van Bauman Teach, who passed away September 8th, after an illness of three weeks.

Professor Teach was born January 6th, 1898, at Pleasant Hill, Ohio, the son of Sarah Aldridge and Charles H. Teach. His father was for many years the principal of various schools in Ohio. Professor Teach graduated from the high school at Pleasant Hill in 1915, and when his family moved to Columbus, Ohio, he entered Ohio State University. He received his B.A. degree there in 1919, his B.E.E. degree in 1921, and his M.Sc. degree there in 1923. He had fulfilled all the requirements of a course leading to a Ph.D. degree at the University of Chicago at the time of his death.

The teaching experience of Professor Teach has been long and varied. From 1921 to 1923 he was instructor in mathematics at Ohio State, and in 1925 took over the same position at Yale. He came to Armour Institute in 1927 as an Assistant Professor, and in 1931 became Associate Professor of Mathematics.

He was a member of the following fraternities: Phi Kappa Tau, Tau Beta Pi, Sigma Xi, Eta Kappa Nu, and Pi Nu Epsilon. He held membership in various mathematical societies, including The American Mathematical Society, Mathematics Association of America, and the Chicago Men's Mathematics Club.

University of California.—The Engineering Materials Laboratory is conducting investigations for the Boulder Dam, the Metropolitan Water District of Southern California, and other western enterprises, emphasizing at present a study, among others, of Blended Cements and the future outlook of these products.

Our Department of Mechanical Engineering is cooperating with the War Department, Corps of Engineers, Western Division, in the study of models of harbor developments for the mouth of the Columbia River and other western ports. For this purpose a laboratory on large scale is nearing completion.

University of Iowa.—*Faculty:* Professor S. M. Woodward, head of the department of mechanics and hydraulics and director of the Iowa Institute of Hydraulic Research was given leave of absence for the year to serve as engineer for the Tennessee Valley Authority and as a Member of the Mississippi Valley Committee.

Mr. Adolph F. Meyer, Consulting Engineer of Minneapolis, and formerly associate professor of hydraulic engineering at the University of Minnesota, has been appointed Professor of Hydraulic Engineering, part time. Prof. F. T. Mavis was designated acting head of the department. Prof. Woodward will return for a brief period each semester to lecture and confer with graduate students.

Prof. G. J. Keller, associate professor of mechanical engineering was given leave for the first semester in order that he may con-

tinue as the engineer in charge of F. E. R. A. for the State of Iowa. Mr. Edward Anderson has been appointed associate professor in his place during his absence. Professor Anderson is an alumnus of the University of Wisconsin, taught at his alma mater eight years, was associate professor at the University of Nebraska and later professor at the University of Tulsa. He has had practical experience in power and petroleum engineering.

Mr. Wm. J. Gallagher was appointed assistant in engineering drawing. Mr. Gallagher received his B.S.C.E. at Iowa in 1932 and since then has been in practical engineering work at Davenport.

A. H. Holt was advanced from associate professor to professor of civil engineering. R. M. Barnes was advanced from associate professor to profession of industrial engineering. C. J. Posey was promoted to be assistant professor of mechanics and hydraulics.

Prof. H. O. Croft, head of the department of mechanical engineering, represented the American Society of Mechanical Engineers at the the combined meeting of la Associacion de Ingenieros y Arquitectos de Mexico at Mexico City during the summer. He presented a paper on the "Aerodynamics of Dust Particles."

E. L. Waterman, professor of sanitary engineering, served as consulting engineer for the state board of health of Vermont during the summer.

Dr. R. M. Barnes, professor of industrial engineering, served as expert on time studies for the Eastman Kodak Co. during the summer.

Prof. J. W. Howe and Mr. O. J. Baldwin assisted the State Planning Board in connection with the study of water resources of the state.

Graduate Students: An unusually large number of students from foreign countries have enrolled at Iowa for graduate work. The countries represented include England, Germany, Austria, Turkey, and China.

Several engineers of rather mature experience are included in the graduate group.

Equipment: The television experimental broadcasting equipment has been increased in power and the facilities in the illumination laboratory extended in the electrical engineering department.

A technichians' shop has been installed in the hydraulics laboratory through the agency of the Corps of Engineers.

More adequate apparatus for making photo-elastic observations was installed by the Chemical Engineering department during the summer. Also equipment for experimental studies of filter sands is being built up.

Some extensions of facilities in the pneumatics laboratory of

the mechanical engineering department have been installed. Also a 25 cu. ft. gasometer is not being installed for accurate measurement of air at low pressure.

Kansas State College.—The engineering division suffered a serious loss on August 10 in the death of Professor J. P. Calderwood, Head of the Department of Mechanical Engineering. He had been a member of the staff since 1918, and head of the department since 1922. Although an able administrator, a forceful teacher and a tireless research worker, he was best known for his authorship of widely used college texts on Thermodynamics and Steam and Gas Power. Professor A. J. Mack is acting as head of the department at present.

Assistant Professor L. B. Smith resigned last summer to accept the position of Head of the Department of Architecture at the University of Nebraska. His place has been filled by Charles L. Morgan of Chicago with the rank of Associate Professor. Professor Morgan was formerly associated with Frank Lloyd Wright and is widely known as an artist and lecturer.

Dr. Fritz Moore, recently on the staff of the University of Illinois, has been appointed Professor and Head of the Department of Modern Languages in place of Dr. J. V. Cortelyou, resigned.

Captain L. R. Crews, C. A. C,, has been appointed Assistant Professor of Military Science and Tactics in place of Captain Ellsworth Young, transferred.

Dr. Milo J. Stutzman has been added to the staff as instructor in metallurgy and metallography to fill the vacancy caused by the resignation of Instructor F. F. Greeley.

June Roberts has been appointed Temporary Instructor in Agricultural Engineering in place of Professor C. A. Logan who is on leave supervising soil erosion control work in Jewell County.

Two graduate research assistantships have been created on the staff of the Engineering Experiment Station for 1934–35. These have been filled by L. W. Hulburt in Agricultural Engineering and N. J. Mellies in Electrical Engineering.

A disastrous fire, on August 8, destroyed Denison Hall with a complete loss of building and equipment. This building housed all of the Physics Department and a large share of the Chemistry Department including general offices, class rooms and physical, organic, quantitative and research laboratories. Two small adjacent buildings which contained chemistry laboratories have been made to serve the needs of the Chemistry Department for emergency student laboratory space, while recitation classes and research work of the department have been crowded into the agricultural building. Three temporary laboratories have been equipped for the Physics Department in the agricultural building.

All classes originally scheduled are being held. A large increase in enrollment in the freshman class has made the situation particularly difficult in the chemistry work.

University of Kansas.—Professor Herbert Allen Rice, Professor of Civil Engineering and head of the Department at the University of Kansas, died, following a minor operation, on July 27, 1934. He had been ill but a short time and his sudden death came as a distinct shock to his many friends. Professor Rice joined the faculty of the School of Engineering and Architecture at the University of Kansas in 1905 and served that university continually over a period of 29 years until his death. His special subject was Structures and his ability as an instructor is reflected in the structural work of many of his former students. He joined the Society for Promotion of Engineering Education in 1915 and he always maintained a keen interest in the work of the society.

Massachusetts Institute of Technology.—Rapid progress in the art of lighting and the promise of still more significant developments in the future has led to the introduction of a comprehensive four-year course in illuminating engineering at the Massachusetts Institute of Technology, Professor Dugald C. Jackson, head of the department of electrical engineering announced.

Professor Parry H. Moon, who has already made distinguished contributions in the field of electrical engineering, designed and will be in charge of the course. Combining the elements of engineering, architecture, and business, it is thought to be the first course of its kind in the country.

Recent advances in illumination, as seen in the new gaseous-conduction lamps, highway lighting, built-in lighting systems for interiors, and improved devices for the measurement of light, have indicated the need for electrical engineers with additional training in art, architecture, color, and the conservation of eyesight.

Technology's new course will be based on a broad training in English, mathematics, history, economics, humanics, public speaking, and psychology, as well as freehand sketching, modeling, history of architecture, and European civilization. The work in architecture and color will start early in the course, to continue through the later years parallel with technical instruction.

Specialization will begin in the third and fourth years, when the work will include principles of electrical engineering, optics, planning principles, estimating, and electrical equipment of buildings. The science of seeing, the calculation of illumination, principles of incandescent and gaseous-conduction lamps, and the design of interior and exterior lighting systems will also be treated.

NEW MEMBERS

BLOXSOME, JOHN L., Assistant Professor of English, Rose Polytechnic Institute, Terre Haute, Ind. John White, Carl Wischmeyer.

BRELAND, JAMES E., Instructor in Engineering Drawing, A. & M. College of Texas, College Station, Texas. Alva Mitchell, H. C. Spencer.

BRENTON, WALTER, Chief Engineer, Portland General Electric Co., 922 Electric Bldg., Portland, Ore. R. H. Dearborn, F. O. McMillan.

CREWS, L. R., Capt. Military Science and Tactics, Kansas State College, Manhattan, Kansas. F. F. Frazier, L. E. Conrad.

DAVIDSON, ARTHUR J., Instructor in Civil Engineering, University of Idaho, Moscow, Ida. I. C. Crawford, R. H. Hull.

DOWNING, DONALD G., Instructor in Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. J. H. Whenman, G. H. MacCullough.

DUNHAM, CLARENCE W., Assistant Engineer, Design Division, Eng. Dept., Port of New York Authority, New York City. L. W. Clark, G. K. Palsgrove.

DUNLAP, ARCHIBALD L., Associate Professor of Mechanical Engineering, Tulane University, New Orleans, La. J. M. Robert, A. M. Hill.

ELLIS, CHARLES A., Professor of Structural Engineering, Purdue University, Lafayette, Ind. A. A. Potter, Justus Rising.

FAITH, WILLIAM L., Assistant Professor of Industrial Chemistry, Kansas State College, Manhattan, Kansas. F. F. Frazier, L. E. Conrad.

FITHIAN, JAMES H., Associate Professor of Mathematics, Newark College of Engineering, Newark, N. J. F. N. Entwisle, P. E. Schweizer.

FOWLER, RUSSELL W., Assistant Professor of Drawing, University of Wisconsin, Madison, Wis. B. G. Elliott, F. E. Turneaure.

FRECKER, G. ALAIN, Lecturer in Engineering, Memorial University College, St. John, Newfoundland. F. H. Sexton, F. L. Bishop.

HOWE, JOSEPH W., Assistant Professor of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa. F. T. Mavis, C. J. Posey.

KISSAM, PHILIP, Assistant Professor of Civil Engineering, Princeton University, Princeton, N. J. (Re-instatement.)

LAUBACH, MERIT L., Head, Industrial Arts, State Teachers College, Terre Haute, Ind. H. M. McCully, F. L. Bishop.

MCCOMBS, GLENN C., Instructor in Mechanical Drawing, Carnegie Institute of Technology, Pittsburgh, Pa. H. M. McCully, F. L. Bishop.

MILLER, HARRY, Instructor in Agricultural Engineering, University of Idaho, Moscow, Ida. R. H. Hull, H. Beresford.

MILTON, HUGH M., JR., Acting Dean, Engineering School, New Mexico State College, State College, N. M. H. M. McCully, F. L. Bishop.

MORGAN, CHARLES L., Associate Professor of Architecture, Kansas State College, Manhattan, Kansas. M. A. Durland, L. E. Conrad.

MUNSON, THURMOND A., Professor of Hydraulic Engineering, A. & M. College of Texas, College Station, Texas. J. J. Rickey, C. W. Crawford.

NEUS, ENGELBERT, Professor of Drafting, College of the City of New York, New York City. H. M. McCully, Fred. Skene, J. C. Rathbun.

NORTHRUP, RALPH T., Assistant Professor of Engineering Drawing, Wayne University, Detroit, Mich. D. L. Perkins, A. R. Carr.

PAXTON, CHAS. H., Associate in Mechanic Arts, University of California at Los Angeles, Calif. H. M. McCully, F. L. Bishop.

SASHOFF, STEPHAN P., Assistant Professor of Electrical Engineering, University of Florida, Gainesville, Fla. B. R. Van Leer, J. Weil.

SCHOWALTER, C. H., Instructor in Mechanical Engineering, University of Idaho, Moscow, Ida. H. F. Gauss, R. H. Hull.

SMITH, LINUS B., Professor and Chairman, Dept. of Architecture, University of Nebraska, Lincoln, Nebr., O. J. Ferguson, H. J. Kesner.

SUBLET, FRANK G., Lecturer in Electrical Engineering Design, University of Melbourne, Kew, Melbourne E. 5, Australia. A. D. Moore, L. N. Holland.

TYRRELL, CECIL C., Instructor in Mechanical Engineering, University of Maine, Orono, Maine. M. J. Sweetser, I. H. Prageman.

WOODROW, JAY W., Professor and Head, Department of Physics, Iowa State College, Ames, Iowa. (Re-instatement.)

37 new members 1934–35

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

High School Drawing: In 1910 26 per cent of the students entering the College of Engineering at the University of Minnesota had four years of high school drawing. Last year less than 1 per cent had had four years of high school drawing. Moreover, 55 per cent of this same group (1933–'34) had had no high school drawing; 80 per cent had had no drawing whatever or not more than one year of it. One wonders if such a decrease as indicated at Minnesota is general; and if so what, if anything, should be done about it.

Certainly we have all heard arguments pro and con about drawing in high school as a factor in the preparation of engineering students. Some teachers of engineering drawing believe high school training in drawing is a great advantage to the engineering student; others declare their experiences indicate otherwise. After hearing the arguments an impartial listener is inclined to the belief that it depends very largely upon what kind of a high school course and what kind of high school training the boy has had whether you are on one side of the argument or the other.

Be that as it may, however, this fact is evident: Colleges of Engineering can ill afford to cut down on the all too scant time now allowed for the teaching of engineering drawing and allied subjects if the evidence from Minnesota indicates a tendency in our high schools. Departments of Engineering Drawing are doing, on the whole, an excellent job of training young engineering students to draw. If these students are coming to college with less and less experience in drawing, certainly engineering administrators must cooperate with drawing departments in seeing to it that training in one of the basic fundamentals of engineering communication is allotted a reasonable share of the student's time.

Not only should engineering drawing be well taught in the early stages of the engineering course, but the teachers of advanced subjects should insist upon its use and accept only high standards of work.

SECTIONS AND BRANCHES

The fall meeting of the **New England Section** of the Society was held at Rhode Island State College, Saturday, October 20th. There were 181 members and guests representing 19 colleges in attendance.

Two conferences were held in the morning. Professor Carlton E. Tucker of M. I. T. presided at a discussion of the teaching of Electronics and Electrical Communications and Professor Arthur E. Norton of Harvard presided at a discussion of the teaching of Applied Mechanics. These discussions were an innovation for this Section and were enthusiastically attended by over fifty members in each conference.

The afternoon session was called to order by the Chairman, Professor James A. Hall of Brown University. After a cordial message of welcome from the President of Rhode Island State College, R. G. Bressler, General R. I. Rees read a paper entitled "What New Factors Should Business Consider in Selecting College Graduates." This paper dealt with a study of the correlation between a college graduate's success in the Bell System, as measured by his salary, and his scholastic and extra curricula activities. General Rees also reported the surprising results of the correlation between a man's success and the institution from which he was graduated. The study showed that, in general, the greater a man's academic and extra curricula success in college, the higher his position in the company. The study also showed that graduates from some institutions tended towards more success than graduates from others even though their undergraduate academic standing were the same. The paper was illustrated by slides and its great interest was shown by the discussion which followed.

The next paper, "Five-Year Course in Engineering at M. I. T," was presented by Professor Dugald C. Jackson, Department of Electrical Engineering and Professor Ralph E. Freeman, Department of Economics, of M. I. T. Professor Jackson presented the reasons for adopting the new optional course and Professor Freeman discussed its set-up. The new course includes essentially the same professional studies as at present exist in the departments of engineering and natural science, with the addition, beginning in the third year, of a graduated program of subjects chosen from the field of social science.

After a discussion of the new course, Professor R. H. Frazier, also of M. I. T., read a paper on "Examinations for Honor Stu-

dents in Electrical Engineering at M. I. T." This paper presented the system used in choosing honor students at the end of the sophomore year as well as the conduct of the conferences which take the place of formal class room work for the remainder of the undergraduate course. It was the opinion of the speaker that the honor students receive a more comprehensive grasp of the subject from this system than could be acquired in regular class work. A discussion of the honor system and method of operation followed Professor Frazier's paper.

At the end of the afternoon session a short business meeting was held and Carl S. Ell, Vice President and Dean, Northeastern University, was elected Chairman and Frank W. Garran, Dean, Thayer School of Civil Engineering, was elected Secretary for the ensuing year.

At the evening meeting Professor J. P. Den Hartog of Harvard University gave a very interesting and entertaining Demonstration of Models in Dynamics. No small part of the interest was due to the demonstration of the use of a stroboscope in the study of practical engineering problems.

The following resolution presented by Dean Case of the University of New Hampshire was passed at this meeting: "The New England Section of S. P. E. E. would rejoice unanimously to have the pleasure of entertaining the Society's Annual Convention of 1936 within its area, as for illustration at Boston with M. I. T. as convention center; and the Engineering Schools of New England undertake to give full aid in making such a convention a success."

FRANK W. GARRAN,
Secretary.

BOOK REVIEWS

Building an Engineering Career. C. C. WILLIAMS, Dean, College of Engineering, State University of Iowa. McGraw Hill Book Company, Inc. 1934.

Those of us who are in contact with engineering students during their first year in college realize what vague notions most of them have as to what engineering is about. For the most part their coming to college to study engineering has been brought about by some trivial incident; their liking for making radio sets or model airplanes; the advice of their high school science teacher; or having an uncle who is a successful engineer. Time and time again they come to my office to ask me to decide for them if they should go ahead in this or that department of engineering, or if indeed they should continue in the engineering school. To one befuddled boy who came in several weeks ago I gave Dean Williams' book and asked him to read it faithfully, two or three chapters a day. Some time later I found the book on my desk with this note attached:

"This book has given me a real notion of what engineering is all about."

Since the book is frankly written for and to the young man entering college, it appears that this boy's reaction to it is a better appraisement of its value than anything which can be written by the mature engineer or educator.

Part I of the book tells of the origin of and the evolution of the branches of engineering, and of the objectives of a college course in engineering. Part II gives an interesting historical development of several broad fields largely concerned with engineering, as Machines, Heat Energy, Electrical Engineering, Transportation and Communication. I like the plan of putting these broad concepts of engineering ahead of a discussion of the several definite branches of engineering, which follows in Part III. Here also, in non-technical language are described some achievements in the several divisions of engineering. The descriptions are clarified by photographs and drawings.

In engineering schools having an orientation course in the freshman year, Dean Williams' book may well be used as a text. At least, every engineering department should have a copy to loan to the boys who are puzzled about engineering. Most high school vocational advisors could read the book with profit.

E. A. HOLBROOK

Government and Technology. WILLIAM BEARD, Instructor in Govenment, California Institute of Technology. The MacMillan Company, New York. 599 pages. $3.75.

The engineer of the future must consider economy as well as efficiency. To the questions, "Is the project feasible?" and "Will it pay?"—must now be added, "Is it in line with social interest?"

Professor William Beard, like his father, Charles A. Beard, has a natural interest in the government of the United States. In "Government and Technology" he clearly shows the effects of technology on government and the increasing importance of government as a factor in engineering work.

The principles of Civics are reviewed from an engineering viewpoint. Such matters of current interest as government control or operation, Civic and National planning and the balancing of government budgets are discussed in a fair and non-partisan way. An exceptional bibliography is included.

Stimulating and up-to-date in thought, well-organized and logical in form, and forward-looking in spirit, this book should be read by all engineering students as a part of their preparation for engineering work. It will prove of no less value and perhaps of more immediate interest to practicing engineers who face the realities of a changing order.

C. S. COLER

The Poetry of Mathematics and Other Essays. DAVID EUGENE SMITH. New York, Scripta Mathematica, 1934. v + 90 pp.

This graceful little volume is the first of a series to be published by Scripta Mathematica "dealing with the history and philosophy of mathematics and with its relations with the other great activities of the human spirit." The words of the preface still further indicate the purpose of this and the succeeding volumes, namely, "to furnish at a nominal price material which will interest not only teachers of mathematics but all those who recall their contact with the subject in their school or college days."

While reading the initial essay, which lends its title to the book, one recalls the statement of Wordsworth that "poetry is the impassioned expression which is in the countenance of all science," and again, "poetry is the breath and finer spirit of all knowledge." Both these remarks are just and true, though their application to the abstract knowledge called mathematics is likely to be considered far-fetched by all except those who, like our author, appreciate both the nature of poetry and the nature of mathematics. This essay should in great measure help us to acquire that precious dual insight.

Other essays follow entitled: The Call of Mathematics; Religio Mathematici; Thomas Jefferson and Mathematics; Gaspard Monge, Politician.

The essay on Jefferson will probably bring a surprise to many. It reveals one of our greatest statesmen as a man who, though not a mathematician in a strict sense, did nevertheless "appreciate the beauties, the grandeur, the values, the classics and the uses of mathematics, and did much to give to the science a recognized standing as a university subject."

This book, though small, is very good. It instructs and inspires us in that manner full of charm which we long since came to associate with the writings of David Eugene Smith.

A. E. STANILAND

Problems in Engineering Thermodynamics and Heat Engineering. CHARLES W. BERRY, CARL L. SVENSON, AND H. CARLTON MOORE. John Wiley & Sons, Inc. 178 pages. $1.25.

This book contains 1064 problems covering every phase of heat engineering. The principal fields covered by the problems are the first and second laws of Thermodynamics, perfect gases, internal-combustion engines, vapors, the flow of fluids, steam turbines, vapor cycles, steam engines, fuels and combustion, air and vapor mixtures, air compressors, refrigeration, heat transmission, heating and ventilation, and mechanical engineering equipment.

The authors have included answers to about one-third of the problems. The problems cover theoretical as well as practical aspects of each subject and the range of difficulty of solution is wide enough to permit the book to be used in advanced and specialized courses, as well as in the intermediate courses in heat engineering.

EMORY KEMLER

Lighting Calculations. H. H. HIGBIE. John Wiley & Sons, Inc. 1934. 503 pages. Price $5.00.

At last a text that stresses calculations pertaining to lighting has made its appearance, in the form of "Lighting Calculations," by H. H. Higbie.

The author has divided this text into ten chapters; and since the titles convey the matter they cover, they are listed as follows:

1. Why Bother About Lighting Calculations
2. Illumination and Light Flux
3. Candlepower and point Source of Light
4. Brightness
5. Surface Sources of Light
6. Linear Sources

7. Multiplying Light by Reflections in an Enclosure
8. Utilization Coefficient: Efficiency of the Lighting System
9. Lamps: Light Generators
10. Visual Effectiveness of Lighting

The text is a very complete compilation of the latest lighting data and accepted methods of calculations. In addition to the very fine text matter, there are 61 examples worked out and the author has included 943 problems, most of which are practical applications.

The book should find a use as a text where a thorough course in Illumination is desired; also it will find a field as a handbook on Illumination.

P. E. RUSH

ENROLLMENT IN ENGINEERING SCHOOLS

The attendance and the percentages are given as received from the institutions.

The following table gives the attendance at 68 engineering schools as of October 1, 1934. The table shows the actual attendance by classes, including graduate students, for the current year, and the percentage increase or decrease in each of these classes and as a whole for those institutions which had replied on or before November 1.

F. L. BISHOP, *Secretary*

Institution	Freshman		Sophomore		Junior		Senior		Graduate Students		Special Students		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Akron, Univ.	68	+30	All upper classmen				111	+12	0	0	0	0	179	+19.5
Ala., Univ.	184	+15	128	−25	146	− 3	147	+15	—	—	—	—	605	− 1
Ariz., Univ.	73	+ 1.4	60	+ 9.1	60	− 1.7	47	−13	21	+ 31	11	0	272	+ 1.1
Ark., Univ.	72	+38	47	−20	59	+28	32	−16	1	+100	0	0	211	+ 130
Armour Inst. Tech.	212	−11	212	−13	186	+22	146	−20	16	+ 23	0	0	772	− 7.1
Brooklyn Poly.	123	− 6.1	139	− 7.3	133	+ 4.5	119	+21.8	268	+ 27.6	0	0	782	+ 4.6
Bucknell Univ.	44	−23.8	41	0	25	+ 4	21	—	2	—	0	0	133	−20
Calif., Univ.	214	+36	136	−16	287	− 4	328	+22	65	0	0	0	1,030	+ 8
Carnegie Inst. Tech.	300	− 2	286	+ 4	257	+12	215	+ 9	39	+ 34	15	0	1,112	+ 8
Case Sch. Ap. Sc.	167	+10	149	− 6	132	− 3	122	−16	27	+ 28	0	0	597	− 3
Catholic Univ.	28	−28.2	40	+42.8	31	−29.5	26	− 3.7	2	− 66.6	0	0	127	−10.5
Colo. Mines	179	+ 5.6	122	− .4	123	+ 1.7	88	− .1	7	+ 5	0	0	519	—
Colo., Univ.	180	+42	130	0	118	—	114	—	0	0	0	0	542	+13
Colo. Agr. Coll.	510	+29	292	+ 8	271	0	223	+24	22	0	68	0	1,386	+12
*Columbia Univ.	105	+10	80	− 9	55	+10	72	0	141	—	15	− 6	468	− 4

* Fifth and sixth year students included under "Graduate Students."

* Fifth and sixth year students included under "Graduate Students."

Institution	Freshman		Sophomore		Junior		Senior		Graduate Students		Special Students		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dela., Univ.	47	+31	32	−27	38	−12	27	+ 4	1	+100	0	0	145	− 4
Detroit, Univ.	145	+33	76 (pre-jr.)	+35	47 51	−51 +29	93	−20	0	0	2	0	414	−1.67
Duke Univ.	61	+ 3	45	+40	17	−30	23	−15	0	0	0	0	146	+ 3
Fla., Univ.	195	+66.6	94	− 6.9	64	+ 4.6	68	0	—	—	4	+25	425	+22.8
Ga. Sch. Tech.	618	+49	430	+11	380	− 9	340	−16	15	+ 43	0	0	1,783	+ 7
Hawaii, Univ.	31	+45	19	+15	15	−35	13	+ 8	—	—	—	—	78	+13
Idaho, Univ.	133	+99	59	+ 7.2	67	+ 4.6	55	+44.7	4	+ 33.3	0	0	318	+40
Ill., Univ.	406	+20.8	264	+13.3	231	− 1.7	220	−15.7	94	− 30.9	0	0	1,215	+ 1.2
Iowa, Univ.	100	+12	78	+16	78	+16	65	− 4	46	0	—	—	367	+10
Kans. St. Coll.	274	+64	182	+62.5	127	−18.5	138	0	12	− 52	0	0	733	+22.6
Kans., Univ.	129	+12	121	+30	126	− 6	123	− 6	4	0	3	0	506	+ 5.5
Ky., Univ.	114	+16.3	103	+25.6	62	−24.4	52	−27.8	0	0	0	0	331	− .89
Lehigh Univ.	468	+18.5	314	−12.1	280	+ .4	253	− 3.1	0	0	8	−20	1,323	+ .8
Maine, Univ.	425	+ 2.7	339	− .9	290	−10.7	307	+ .98	26	− 77	34	− 5	1,421	− 2.1
Manhattan C.	55	−15	59	+ 5	51	+44	36	−25	8	− 33	0	0	209	—
Marquette Univ.	98	+17	78 (pre-jr.)	+ 5	78 66	+26 −30	60	− 2	0	0	2	0	382	+ 4.1
M. I. T.	548	+10.7	461	− 4.6	492	− 3.3	478	−19.5	480	+ 1.3	0	0	2,485	− 3.8
Mich. St. Coll.	166	+31.5	104	− 3.7	118	+14.5	88	− 7.4	14	+ 16.5	0	0	490	+10.2
Mich., Univ.	329	+30.5	326	+22	351	+11.4	339	−12.4	140	− 13.6	0	0	1,485	+ 7.4

Institution	Freshman		Sophomore		Junior		Senior		Graduate Students		Special Students		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Mo., Univ.	96	+81	68	−14	69	+ 4	53	− 8	0	0	0	0	286	—
Mo. Mines	91	+34	75	+ 4	92	+ 1	91	− 6	19	+ 74	16	−16	384	+ 7
Mont. St. Coll.	130	− 7	106	+29	43	− 2	60	0	1	− 85	0	0	340	+ 4.1
Newark Coll. E.	246	0	170	+15	130	−18	105	+17	0	0	0	0	651	0
N. M., A. & M.	55	+96.4	22	−27.3	29	0	33	+21.2	0	0	0	0	139	+23
N. M., Mines	50	+17	36	+17	23	− 3	23	+ 3	0	0	2	− 7	134	+27
N. C., Univ.	107	+37.2	60	− 1.6	45	−13.5	44	+29.4	5	− 4.4	—	—	261	+11.1
N. D. Ag. Coll.	99	+65	49	+ 4	46	−37	69	−30	0	0	0	0	263	+ 2
No. East. Univ.	339	+15	266 (Middlers)	−16	273 237	+ 4 −20	248	0	0	0	0	0	1,363	− 4
No. West. Univ.	76	+ 2	55	−22	48	+10	47	+15	12	− 10	0	0	238	—
Ohio State Univ.	447	+73	343	−11	299	+ 3	254	− 4	55	− 11	0	0	1,398	+10
Okla. A. & M.	292	+46.7	199	+14.3	154	+10	123	+ 3.3	0	0	5	0	773	+21.3
Ore. Ag. Coll.	207	+56	127	+27	88	−26	87	− 9	12	+ 33	0	0	521	+14
Pa. St. Coll.	270	+18	213	− 9	183	− 5	175	−20	0	0	0	0	841	− 4
Pittsburgh, U.	219	+70	127	− 1	126	− 4	132	−21	61	− 1	—	—	665	+ 7.4
Princeton Univ.	78	0	57	− 3	42	−20	48	+20	17	0	0	0	242	− 3
Purdue Univ.	721	+27	539	+10	462	−10	444	− 2	0	0	0	0	2,171	+ 7
Queen's Univ.	129	− .77	114	+ .88	106	+17.7	88	+15.8	14	− 22.2	—	—	451	+5.13
R. I. St. Coll.	93	+12	55	−26	64	−14	49	+ 6	0	0	0	0	261	—
Rose Poly. Inst.	54	+ 6	41	−16	39	−30	53	+ 2	0	0	0	0	187	−10

Institution	Freshman		Sophomore		Junior		Senior		Graduate Students		Special Students		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
S. D. Mines	102	+29	77	+33	40	− 9	42	−16	1	0	5	− 7	267	+12
So. Meth. Univ.	33	+43.5	17	−32	19	− 9.5	26	+62.5	0	0	—	—	111	− 3.5
			(pre-jr.)		16	−46.6								
Texas A. & M.	664	+49	339	+31	209	+ 6	177	− 3	26	− 13	1	0	1,416	+30
Toledo, Univ.	130	+36	46	−18	38	0	30	0	1	0	—	—	246	+15
Tulane Univ.	113	+20	72	+ 4	58	0	49	− 6	5	0	0	0	297	+ 9
Tufts Coll.	86	−15.6	87	− 2.2	79	−19.3	103	+37.3	0	0	0	0	355	− 3.5
Vt., Univ.	37	−14	26	−30	33	+18	27	+ 4	0	0	0	0	123	− 9.6
Va. Poly. Inst.	363	+20.6	226	+ 9.3	156	0	160	+14.3	42	+ 16.7	0	0	947	+13
Wash. U. (St. L.)	113	− 5.8	77	−19.8	98	− 1	50	−15.2	13	+ 20	21	+50	372	− 6.3
Wash., Univ.	461	+39	261	+43	170	−10	164	− 4	34	− 3	0	0	1,090	+19
Wis., Univ.	300	+42	194	+ 9	207	− 5	216	− .5	50	− 10	0	0	967	+10
Worcester P. I.	195		116		149		106		13		0		579	
Wyo., Univ.	78	+110	32	0	30	+87	23	−18	0	0	4	0	167	+41
Yale Univ.	—	—	54	−20	56	+ 3	46	−16	67	+ 50	0	0	223	0
	13,275		9,452		8,868		7,923		1,903		216		41,750	

The percentage change, over last year, in the freshman, sophomore, junior and senior classes in these institutions is approximately:

Freshman	+24.2%
Sophomore	+ 7.5%
Junior	+ 8.0%
Senior	− 1.9%
Total	+10.6%